# Chapter Six: Reasonably Foreseeable Cumulative Effects of Leasing

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# Chapter Six: Foreseeable Cumulative Effects of Leasing

AS 38.05.035(g) requires ADNR to consider and discuss the reasonably foreseeable cumulative effects of oil and gas exploration, development, production, and transportation on the sale area, including effects on subsistence uses, fish and wildlife habitat and populations and their uses, and historic and cultural resources. However, ADNR is not required to speculate about possible future effects subject to future permitting that cannot reasonably be determined until a project or proposed use for which a written best interest finding is required is more specifically defined. AS 38.05.035(h)

Accordingly, this chapter sets out relevant and important information which is currently known to ADNR about the Cook Inlet Areawide sale. It also considers and discusses the reasonably foreseeable effects of additional activities which may result from Cook Inlet Areawide related oil and gas exploration, development, production and transportation. By necessity, some of this discussion is general in nature. While certain activities are reasonably foreseeable because they would be components of any oil and gas activity in the Cook Inlet and Susitna region, activities specific to certain areas or tracts are not reasonably foreseeable because the odds of finding and developing commercially exploitable quantities of oil or gas from any particular tract are slim.

ADNR will require numerous general mitigation measures which will be applicable to any Cook Inlet Areawide sale activity, no matter where in the sale area. Mitigation measures, lessee advisories and existing laws provide a floor of protection, to be enhanced by more specific mitigation measures as required by any particular plan of operation which may eventually be proposed.

Cook Inlet is a mature petroleum basin with declining fields. It is impossible to predict whether a commercial discovery of oil or gas will ever be made in the Cook Inlet or Susitna areas. As the population of Alaska expands and regional petroleum supplies are depleted, new incentives to explore for and develop oil or gas could result in an increase in exploratory activity. New discoveries of oil or gas may be made, and development may be proposed.

Potential bidders weigh the costs and benefits of obtaining and keeping a lease. They acquire and analyze existing data, conduct geophysical exploration, estimate the volume and type of recoverable reserves, estimate the cost of developing reserves, and attempt to calculate the expected return on their investment. These considerations may be weighed in light of other factors, such as the state's leasing policy, schedule of future sales, or competing projects, such as developing prospects overseas. Considering all these variables, it is not easy to predict which tracts will be bid upon and leased.

Strategies used to explore for, develop, produce, and transport potential petroleum resources can vary depending on factors unique to the individual tract, lessee, operator, or discovery. If a commercially developable deposit were found, any development would require construction of one or more drillsites. Construction of onshore or offshore pipelines would be likely and other production and transportation facilities would also probably be necessary. New roads may also be required, and machinery, labor, and housing would be transported to project sites or otherwise obtained to support the project.

The state of Alaska as a whole, and residents of the tri-borough Cook Inlet/Susitna regions (MOA, MSB, KPB) may experience effects of activities following this sale in both monetary and non-cash terms. Impacts to the entire region may be minuscule. However, local impacts might be significant. Potential effects include:

- Erosion
- Use conflicts
- Disturbance to wildlife
- Oil spills
- Alteration of hydrology
- Loss of fish and wildlife
- Increased noise and traffic
- Habitat loss or change
- Environmental studies
- Water quality changes
- Chemical/pollutant releases
- Impacts to human built environment
- Air quality degradation
- Siltation
- Employment opportunities
- Road, dock, airstrip, sanitary & utilities construction
- State petroleum tax & royalty revenues
- Local oil and gas property tax revenues

Most adverse effects are temporary and occur most often during development, and less often during exploration and production phases. In the 30-year life of a typical field, development may last just two years. Positive effects occur at all phases and fiscal benefits of petroleum extraction may last several decades (See Chapter Seven, Fiscal Effects).

Development is dependent on the results of exploration and will not occur unless a commercial discovery is made; engineering, economic, and environmental assessments are completed; and permits are scrutinized and approved by agencies and the public. Exploration activities will likely be conducted during winter, but effects of development, production, and transportation are evaluated as if they occur year-round. All lease-related activities are subject to applicable local, state, and federal statutes, regulations, and ordinances, and subject to lease mitigation measures. Implementation of any exploration and development program must meet the requirements of regulatory agencies prior to approval. Permit requirements must be evaluated in light of the particular activity proposed, and plans of operation must be approved with appropriate project-specific and site-specific safeguards. Chapter Eight includes a growing body of laws regulating oil and gas activities in Alaska.

Despite protective measures, some impacts may occur. In this chapter, potential impacts are discussed, and measures to mitigate future impacts are summarized. For a full text listing of mitigation measures see Chapter Nine.

## A. Development Phases and the History of Drilling and Discovery

This section is divided into two parts. The first section describes current petroleum exploration and extraction methods and operating practices given the existing regulatory (federal, state, local law) regime. This is followed by the history of petroleum exploration, discovery, leasing, and extraction in Cook Inlet. The cumulative effects of post-sale oil and gas activities are also discussed in this chapter.

Following the lease sale, there are three primary phases of industrial activity: exploration, development, and production. The development impact on the environment or “footprint” has become smaller since oil development began in the 1950’s in Cook Inlet. Advances in technology and innovations, especially in drilling have resulted in smaller and fewer gravel pads necessary to develop the same size field. Today’s operations are cleaner as a result of improved waste disposal practices, prompted in part by environmental awareness.

# 1. Post lease sale phases

Post-lease sale activities can include geophysical exploration, exploration-well drilling, field development, and production. Directional, horizontal, and extended-reach-drilling is also discussed. Transportation of oil and gas is discussed in Chapter Five.

## a. Geophysical Exploration

Geophysical exploration of the area considered in this finding has been ongoing since prospectors discovered oil seeps in the early 20$^{th}$ century. Geophysical companies usually conduct seismic surveys under contract with leaseholders. Contracts may have provisions that allow the geophysical company to sell the data to other interested companies. Geophysical programs may take place before or after a lease sale. If sufficient data are already available, additional seismic data acquisition may not be necessary.

Geophysical exploration activities are regulated by 11 AAC 96, and ADNR (DOG, DL, DMWM) tailors each permit approval depending on the specifics of a proposed project. Restrictions on geophysical exploration permits depend on the duration, location and intensity of the project. They also depend on the potential effects the activity may have on important species or human use, such as migrating salmon and commercial fishing. The extent of effects on important species varies depending on the survey method and the time of year the operation is conducted.

Exploration activities may include the following: examination of the surface geology, geophysical survey programs, researching data from existing wells, or drilling an exploratory well. Surface analysis includes the study of surface topography or the natural surface features of the area, near-surface structures revealed by examining and mapping exposed rock layers, and geographic features such as hills, mountains and valleys.

Geophysical surveys help reveal what the subsurface may look like. Before they proceed, companies must acquire one or more permits from the state depending on the timing and extent of the proposed activity. Companies will either gather 2-D or 3-D seismic data. Two-dimensional seismic programs usually have fewer crew members and employ less equipment than 3-D programs.

Land-based seismic surveys are typically conducted in winter and use low ground pressure tracked vehicles or use helicopters in remote operations. The method involves sending energy into the earth using an explosive charge or other energy wave-generating device, such as vibroseis. Vibroseis generates energy waves of continuously varying frequency. Depending on density, waves bounce back from the various rock layers and are received by listening devices called geophones. Impulses are recorded on computer tape, processed on high-speed computers, and displayed in the form of a seismic reflection profile. In another method, explosives are lowered into drill holes and detonated, or they may be suspended on stakes above the ground (Poulter method). The drill holes are drilled with either track-mounted drills or with drills slung into position by helicopters. For 3-D seismic operations, holes are drilled typically 25 feet deep with 5 pounds of explosive set at the base of the hole. Geophysicists then analyze the profile to determine subsurface structures (ARCO, Undated).

Exploration of offshore areas is more difficult since scientists cannot explore the sea bottom in person. They must use a variety of means to gather the necessary information about the area of interest. Side-scan sonar, fathometer recordings, shallow coring programs and geophysical surveys are tools often used in marine exploration programs. Offshore seismic surveys are typically conducted between April and mid-November with the use of airguns to produce the energy impulse. Shore-based helicopters, which can land on the vessel's helideck, resupply the operation and transfer crew when necessary. Marine seismic equipment consists of a sound source (airgun array), sound detectors (hydrophones), amplifiers and recording system, and a navigation system. An airgun array is towed directly behind the ship at a depth of 30 to 40 feet. The airgun array consists of several sub-arrays, each of which contains several airguns of various sizes. Hydrophones are pressure detectors housed in a long streamer cable (up to 2 miles) which is towed behind the ship at depths between 20 and 40 feet. For some seismic surveys, the detectors and cables are placed directly on the bottom where they remain stationary as the shooting boat traverses across them (ARCO, Undated).

Effects of seismic exploration of fish and wildlife are discussed in Section B of this Chapter.

Table 6.1 Activities That May Be Found At Post Lease Sale Phases

| | **Offshore** | **Onshore** |
|---|---|---|
| **Exploration** | permitting<br>environmental studies<br>seismic tests<br>exploratory drilling rigs<br>drilling muds and discharges<br>marine vessels<br>helicopter access<br>floating facilities | permitting<br>water usage<br>environmental studies<br>seismic tests<br>exploratory drilling<br>land clearing<br>drilling muds<br>gravel road beds, ice roads<br>work camp<br>increased air traffic<br>temporary gravel pads |
| **Development** | permitting<br>environmental studies<br>research and analysis<br>onshore facility construction<br>docks, tanker terminals<br>pipelines<br>drilling rigs<br>increased air and vessel traffic<br>platform installation | permitting<br>environmental studies<br>research and analysis<br>gravel pits, pads and roads<br>dock and bridge construction<br>pipelines<br>drilling rigs<br>work camps |
| **Production** | permitting<br>monitoring<br>drill programs<br>reinjection wells: gas and sea water<br>submarine structures or anchors<br>platforms<br>produced water<br>air emissions<br>pipeline maintenance<br>tanker traffic<br>discharge wastes | permitting<br>monitoring<br>well heads<br>reinjection wells: gas and sea water<br>well work over (rigs)<br>gravel pads and roads<br>produced waters<br>air emissions<br>pipeline maintenance<br>work camps<br>trucking wastes |

### b. Exploratory Drilling

If the geologic studies indicate that oil or gas may be present, lessees may initiate the drilling of an exploration well. Drilling is the only way to learn whether commercial quantities of oil or gas are present in rock formations beneath a lease. Drilling wells is expensive, and exploratory drilling normally happens only after the lease is acquired (after mineral rights have been secured) and after preliminary less expensive exploration activities, such as seismic surveys, reveal the most likely places to find oil or gas.

Onshore exploratory drilling operations normally occur in winter to minimize impact. Sometimes temporary roads must be built to the area. Roads are constructed of sand and gravel laid over a liner above undisturbed ground. The drill site is selected to provide access to the prospect to be drilled and, if possible, is located to minimize the surface area that may have to be cleared. A typical drill pad is made of sand and gravel laid over a liner and is about 300 feet by 320 feet. The pad supports the drill rig which is brought in and assembled at the site, if necessary a fuel storage area, and a camp for 50 to 60 workers. If possible, an operator will use nearby existing facilities for housing and feeding its crew. If the facilities are not available, a temporary camp of trailers on skids may be placed on the pad (Chevron, 1991).

Enough fuel is stored on-site to satisfy the operation's short term needs, which amount to about 4,500 gallons of diesel and gasoline per day. The storage area is a diked gravel pad lined with an 80 mil synthetic membrane. Additional amounts of fuel may be stored at the nearest existing facility for transport to the drilling area as needed (Chevron, 1991).

An exploratory drilling operation generates approximately 12,000 cubic feet of drilling solids. The state discourages the use of reserve pits and most operators store drilling solids and fluids in tanks, or in temporary on-pad storage areas until they can be disposed of, generally down the annulus of the well, in accordance with 20 AAC 25.080. If a reserve pit is necessary, it is constructed off the drill pad and could be as large as 5 feet deep and 40 feet by 60 feet. It is lined with an 80 mil geotextile liner to prevent contamination of surrounding soils. Drilling muds and fluids produced from the well are separated and disposed of, often by reinjection at another facility. With appropriate permits, solids may be left in place in a capped reserved pit. If necessary, a flare pit may be constructed off of the drill pad to allow for the safe venting of natural gas that may be encountered in the well. (Chevron, 1991). If the exploratory well discovers oil or gas, it is likely that the gravel pad used for the exploratory well will also be used for development and production operations.

Cumulative effects of mud, cuttings, and produced water discharges into Cook Inlet are discussed in Chapter Five.

Offshore exploratory drilling rigs include floating rigs such as drill ships, semi-submersibles and barges and bottom-supported rigs such as submersibles and jackup rigs. Water depth and bottom conditions determine which equipment will be used. See Table 6.2, Offshore Drilling Units

Jackup rigs have been used in Cook Inlet in the past. These rigs have watertight barge hulls that can float on the surface of the water while the unit is being moved between drill sites. Some units are towed while others are self-propelled. Before the location is finalized, the operator performs a geological hazards survey to make sure that the sea floor can support the rig. The surveys look for shallow gas ($H_2S$) deposits and faults, and are similar to geophysical surveys but involve smaller vessels and shorter tow strings. When the jackup is positioned at the drill site, the legs are jacked down until they rest on the seabed. The hull is then jacked up above the water's surface until a sufficient gap exists to accommodate tides and waves.

Exploratory drilling generates more information for the lessee. Drilling operations collect core samples, well logs, cuttings, and various test results. Cores may be cut at various intervals so that geologists and engineers can examine the sequences of rock that are being drilled. Well logs are records of tests conducted by dropping various instruments into the well bore. Cuttings are fragments of rock cut by the drill bit. These fragments are carried up from the drill bit by the fluids pumped into the well. (Gerding, 1986: 97-174) (ARCO, Undated: 80-84)

The drilling process is as follows:

1. Special steel pipe, conductor casing, is hammered into the sea floor offshore or soil onshore.
2. The bit rotates on the drill pipe to drill a hole through the subsurface rock formations.

3. Blowout preventers are installed on the surface and only removed when the well is plugged and abandoned. Blowout preventers are large, high-strength valves that close hydraulically on the drill pipe to prevent the escape to the surface or into groundwater formations. (ARCO, undated: 80-84)
4. Progressively smaller sizes of steel pipe, called casing, are pushed into the hole and cemented in place to keep the hole from caving in, to seal off rock formations and to provide a conduit from the bottom of the hole to the drilling rig.
5. Well either produces, is capped, or is plugged and abandoned.

Figure 5.2, Wellbore Schematic shows a typical production well schematic for Alaska. If the exploratory well is successful, the operator will probably drill one or two more to delineate the extent of the discovery and gather more information about the field. The lessee needs to know how much oil and gas may be present, their quality, and the quality of the rocks in which they are found.

### c. Development and Production

During the development phase, the operators evaluate the results of exploratory drilling and develop plans to bring a discovery into production. Production operations bring well fluids to the surface and prepare them for transport to the processing plant or refinery. This phase can begin only after exploration has been completed and tests show that the discovery is economically viable. (Gerding, 1986: 177-199)

After designing the facilities, the operators construct permanent platforms (if offshore) or gravel pads (if onshore) and drill production wells. The operator must build production structures that will last the life of the field and may have to redesign and add new facilities for enhanced recovery operations as production proceeds.

If the development area is offshore and not within reach of existing infrastructures, a new platform may be proposed. Existing platforms are constructed onshore, floated to the desired location, sunk, and driven in place. A Cook Inlet platform consists of a steel jacket with legs fastened to the seabed and the topside which houses the staff and equipment necessary for producing oil and gas. Each leg is fastened to the seafloor with piles that penetrate about 135 feet below the surface. The piles serve as drilling slots and conductor pipe. Types of offshore drilling units are listed in Table 6.2.

Table 6.2 Offshore Drilling Units

| Mobile Offshore Drilling Units (MODUs) (exploration) | | | |
|---|---|---|---|
| Type | Sub-type | Support type | Operational Depth |
| Bottom Supported | Submersibles | Posted Barges | water <30 feet |
| | | Bottle-type submersibles | water <200 feet |
| | | Arctic submersibles | Concrete island drilling system (CIDS) (water up to 150’) |
| | Jackups | Columnar legs | water 300’ to 600’ |
| | | Truss legs | water 300’ to 600’ |
| | Inland Barges | | shallow water |
| | Ship-shaped barges and Drill ships | | |
| Semi-submersibles(deep water applications) | | | |

| Offshore Drilling Platforms (production) | | | |
|---|---|---|---|
| Type | Sub-type | Support type | Operational Depth |
| Rigid platforms | Steel-jacket platform (piles) | | > 1,000 feet water |
| | Concrete gravity platforms | | |
| | Steel-caisson platform | Tide and ice resistant (Cook Inlet) | |
| Compliant platforms (moves w/wind, currents & waves) | Guyed-tower platforms | guy wires, clump weights | |
| | Tension-leg platforms | steel tubes to bottom, tensioned by buoyanc | |

Oil and gas production facilities found on the topside of a platform include oil and gas processing facilities to remove some of the water produced with the petroleum, water and sewage treatment equipment, power generators, a drilling rig that can move between legs, housing for about 75 workers, and a helipad. Onshore support facilities include a production facility to receive and treat the oil and gas for transportation to a refinery or other processing facilities; a supply base and vessel to provide the platform with cement, mud, water, food, and other necessary items; a supply vessel to bring the items to the platform; and a helicopter base for transporting crews to and from the platforms (Marathon, 1985:42-53).

Onshore and offshore production operations for natural gas generally follow these steps:

1. Natural gas flows through a high-pressure separator system where any liquids (water, condensate, etc.) are removed. Produced oil goes through a separator to remove the natural gas from the oil.
2. The gas is compressed if necessary.
3. The gas is dehydrated to lower its water content.
4. The gas is then metered, i.e.; the amount of gas produced is measured.
5. It is transported to an onshore facility where it passes through a water precipitator to remove any oil.

Onshore and offshore oil production steps are:

1. Produced crude oil goes through a separator to remove gas from the oil stream.
2. The oil moves to an onshore processing facility via a pipeline.
3. The gas removed from the oil may be compressed and reinjected to keep the pressure up in the producing formation to assist in oil production.

Transportation of oil and gas is discussed in Chapter Five.

The development “footprint” in terms of habitat loss or gravel filling has decreased in recent years as advances in drilling technology have led to smaller, more consolidated pad sizes. A single production pad and several directionally drilled wells can develop more than one and possibly several 640-acre sections. See Figure 6.1, Pad-size Diagram.

Depending on the depth of the reservoir rock and horizontal deviation ability, the area of surface disturbance per acre of habitat can be minimized. Longer horizontal departures also reduce per acre impacts compared to older field developments. See Figure 6.2, Well-reach vs Time. Based on current development practices, surface impact from developing Cook Inlet Areawide tracts is unlikely to exceed 1.9 percent per 640 acre section for any given development on leased and developed onshore acreage.

### d. Directional, Horizontal, and Extended-Reach Drilling

The following section describes potential applications and limitations of directional and extended-reach drilling (ERD) technology as a tool toward mitigating adverse environmental impacts of development. Directional drilling is the ability to steer the drill-stem and bit to a desired bottomhole location. Directional wells are initially drilled straight to a predetermined depth and then gradually curved at several different points to penetrate the reservoir. This is accomplished with the use of a fluid-driven downhole motor (Gerding, 1986).

Directional drilling also allows multiple production and injection wells to be drilled from a single location such as a gravel pad or offshore production platform, thus minimizing cost and the surface impact of oil and gas drilling, production, and transportation facilities. It can be used to reach a target located beneath an environmentally sensitive area and may offer the most economical way to develop offshore oil fields. See Figure 6.4, Directional Drilling Applications**.**

Directional drilling allows a single wellbore at the surface to penetrate oil or gas bearing reservoir strata at horizontal or near horizontal to the dip of the strata. The wellbore is in communication with the reservoir over much longer distances. In developed wells, this can greatly increase production rates of oil and gas or volumes of injected fluids. The completion technique is most commonly applied to low permeability (rock with low capacity for transmitting fluids) or fractured petroleum reservoirs. However, using directional drilling to reach just one target may increase drilling costs relative to a vertical straight hole (Winfree, 1994).

The limitations of directional drilling are primarily dependent upon maximum hole angle and rate of angle change. In directional drilling, it is now common for the drill to go an equal vertical depth related to the horizontal distance from the drill site. That is, a well with a vertical depth of 7,000 feet would have a bottom hole horizontal displacement of 7,000 feet from the drill site (See Figure 6.3, Drill Site Block Diagram). If a potential target is two miles away from the drill site but only one mile deep, directional drilling would be much more difficult and costly (Schmidt, 1994).

The type of geology or rock that must be drilled in order to reach a target may also limit directional drilling. Cook Inlet is particularly difficult because of its many coal seams and faults. Coal and shale deposits tend to collapse and cause the drill string to get stuck. Faults are difficult to track and if a fault is crossed by the drill bit, the type of rock being drilled may suddenly change and a new geologic reference must be established. During this intermediate period in the drilling operation, the driller will not be sure if the desired geologic target was being or could be intersected (Schmidt, 1994). Drill pipe or drill collars can get stuck in the borehole when the hole collapses around the pipe. Stuck pipe can also occur when the borehole becomes oval and drill pipe gets lodged against one side of the hole. Also, pressure differentials in the wellbore make drill collars, and drill pipe irretrievable. The most common cause of hole collapse is the attraction between in-formation salt water, and the water in drilling mud. This is especially common when drilling through shale. Water in the mud has a tendency to transfer to the shale, the shale expands, and small sheets slough off into the hole, causing the pipe to get stuck (Gerding, 1986)

Collisions with neighboring wells can be a problem when drilling multiple boreholes from one surface location. A collision with a producing well could result in a dangerous situation. Anti-collision planning begins with accurate surveys of the subject well and a complete set of plans for existing oil and gas wells (Schlumberger Anadrill, 1993:55).

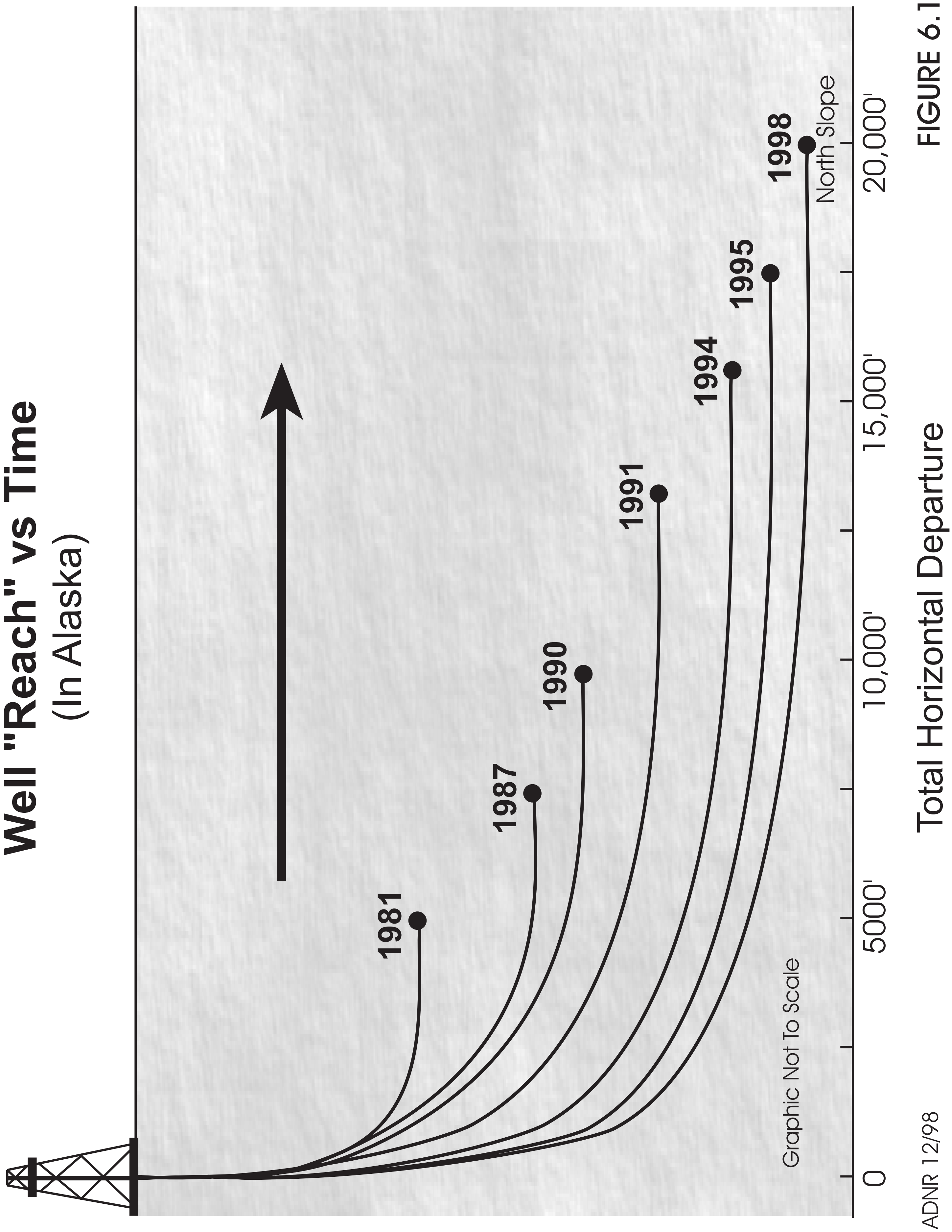
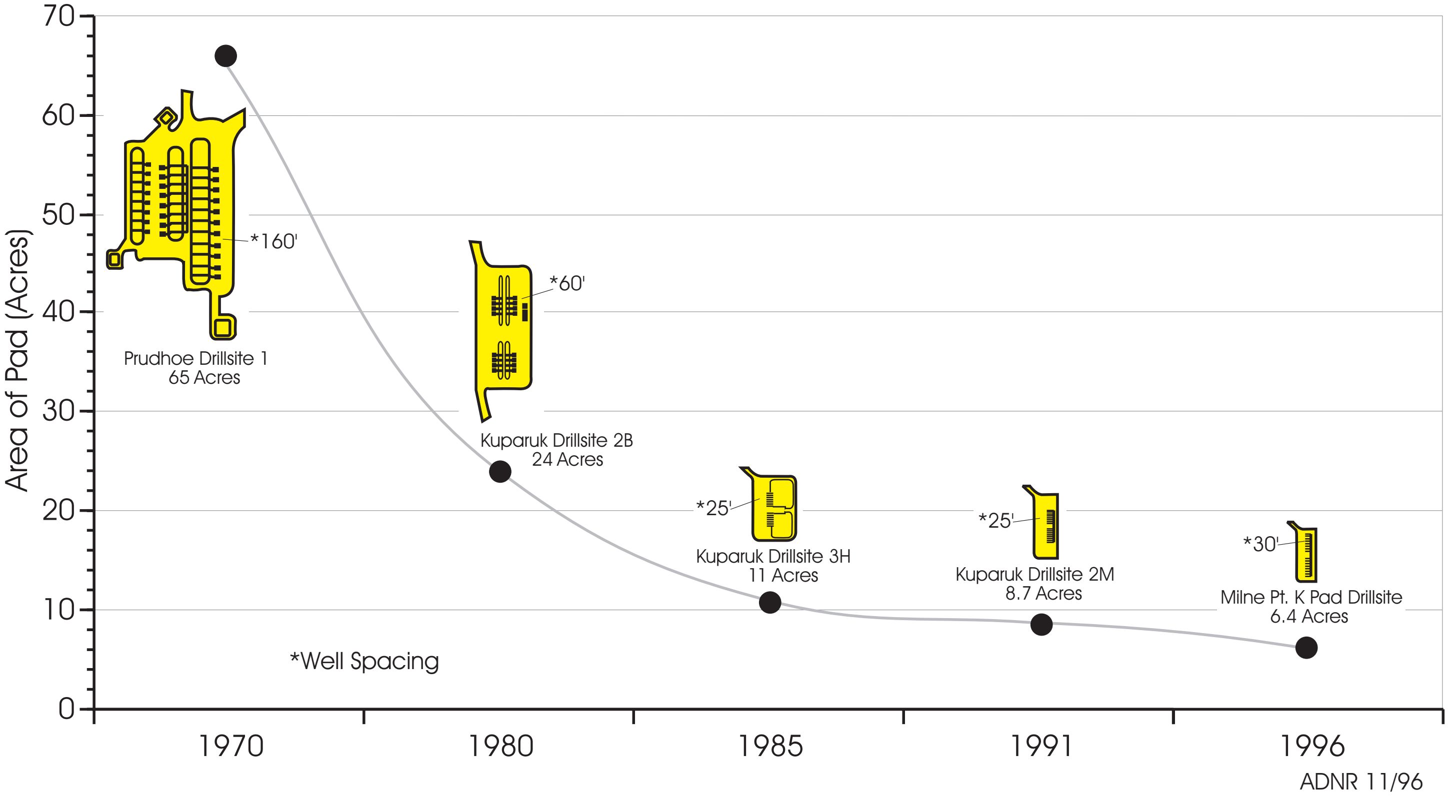
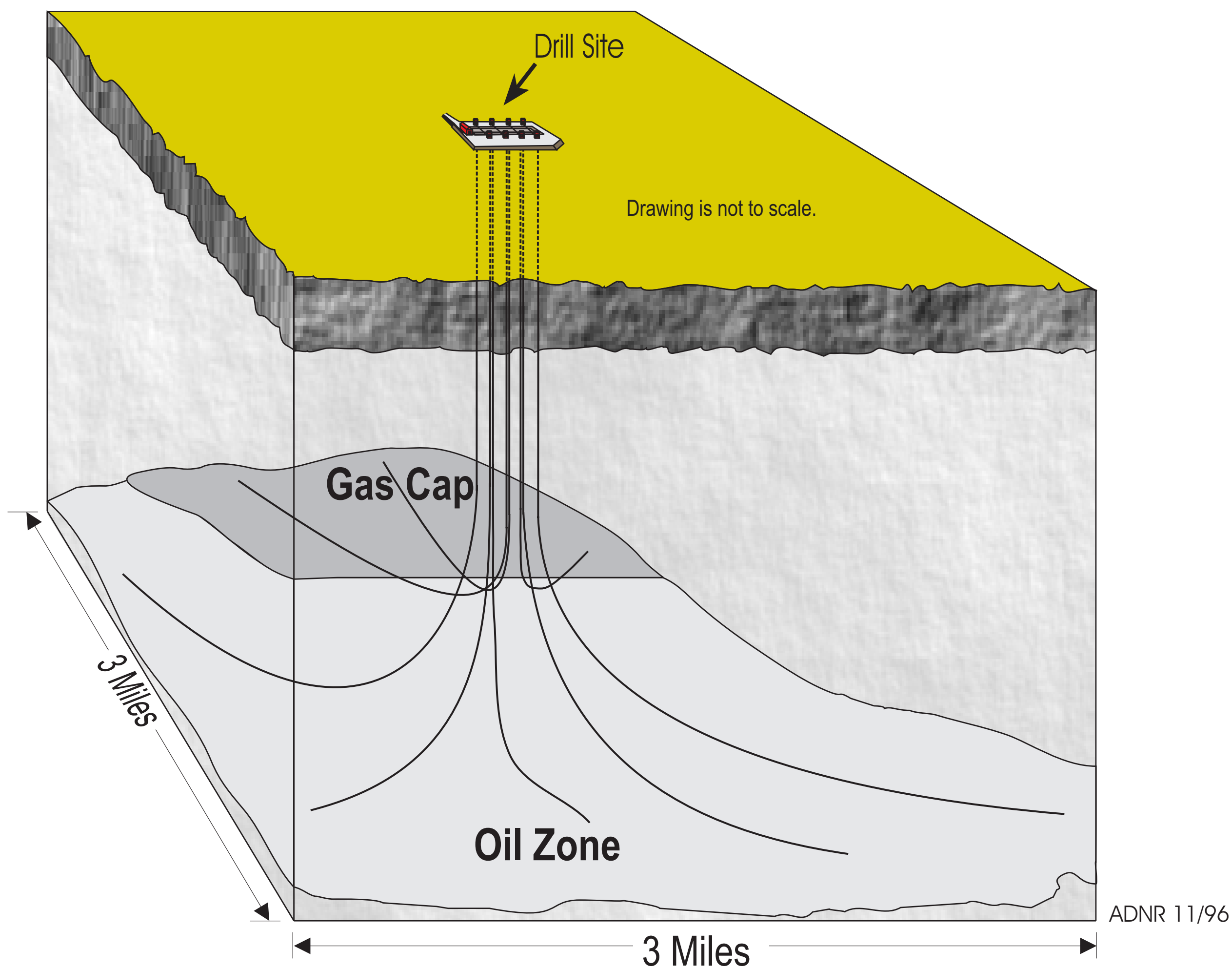

Well "Reach" vs Time
(In Alaska)
1981
1987
1990
1991
1994
1995
1998
North Slope
Graphic Not To Scale
0
5000'
10,000'
15,000'
20,000'
Total Horizontal Departure
ADNR 12/98

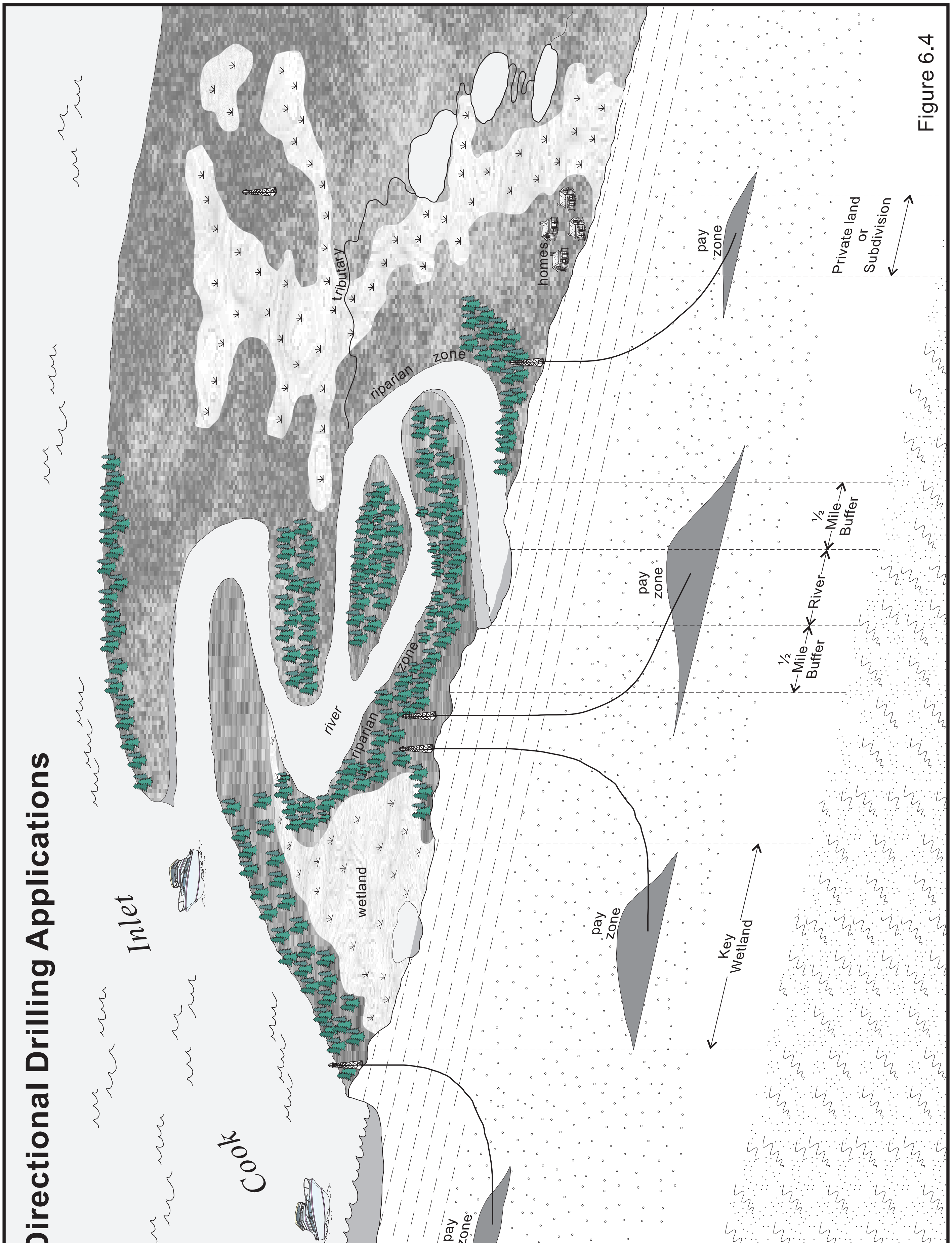
FIGURE 6.1

## FIGURE 6.2 Pad Size Reduction vs. Time




## FIGURE 6.3 Drill Site Block Diagram






Directional Drilling Applications

Figure 6.4

Perhaps the greatest limitation on directional drilling is cost. Although directional drilling may be technically possible it is not always economically feasible. Factors such as where the oil or gas deposit is in relation to the drilling rig, the size and depth of the deposit, and the geology of the area, are all important elements in determining whether directional drilling is cost effective (Winfree, 1994).

Horizontal well drilling, in contrast to directional well drilling, exposes the wellbore to more pay zone, thereby increasing recovery (Judzis, et al., 1997). The fundamentals of drilling horizontal wells include underbalanced drilling, coiled tubing, bit steering, continuous logging (measurement-while-drilling), multi-lateral horizontals, and horizontal completions. Lateral and multi-lateral step-outs are extended-reach wells that branch off a main borehole to access more of the subsurface.
(PTTC, 1996)

Conditions for successful horizontal wells include adequate pre-spud planning, reservoir heterogeneity, drillable lithologies that will not collapse, field storage in matrix and fracture porosity, deliverability through adequate matrix of fracture permeability, and careful cost control (PTTC, 1996).

ERD has evolved from directional to horizontal, lateral, and multi-lateral step-outs. ERD employs both directional and horizontal drilling techniques and has the ability to achieve horizontal well departures and total vertical depth to deviation ratios beyond the conventional experience of a particular field (Gerding, 1986). ERD can be defined in terms of reach/TVD (total vertical depth) ratios (Judzis, et al., 1997). The definition of an ERD well depends on the results of existing drilling efforts in a particular oilfield (Gerding, 1986). Local ERD capability depends on the extent of experience within specific fields and with specific rigs and mud systems. “ERD wells drilled in specific fields and with specific rigs, equipment, personnel, project teams, etc. do not necessarily imply what may be readily achieved in other areas.” (Judzis, et al., 1997:2).

Constraints to successful ERD include downhole drillstring and casing movement, applying weight to the bit, the amount of buckling, and running casing to the bottom. Tension may be a primary concern in vertical wells, but in ERD, torsion may be the limiting factor. Running normal-weight drillpipe to apply weight to the bit in ERD can lead to buckling of the drill pipe and rapid fatigue failure. Conventional drilling tools are prone to twist-off, because of unanticipated failure under high torsional and tensile loads of an extended-reach well (JPT, 1994a). Torque can be significantly reduced with the use of non-rotating drillpipe protectors (Payne, et al., 1995). Advanced equipment for an ERD well may include wider diameter drill pipe, additional mud pumps, enhanced solids control, higher capacity top drive, more generated power and oil-based drilling fluids (Judzis, et al., 1997). ERD requires longer hole sections, which requires longer drilling times; the result is increased exposure of destabilizing fluids to the wellbore (JPT, 1994a). The superiority of oil-based muds versus water-based muds in ERD is widely recognized (Payne, et al., 1995). Water-based muds may not provide the inhibition or confining support of oil-based muds (JPT, 1994a).

Extended-reach drillstring design involves a) determining expected loads, b) selecting drillstring components, c) verifying each component’s condition, d) setting operating limits for rig team, and e) monitoring condition during drilling. Economic issues in drillstring planning include availability, logistics, and cost. Rig and logistics issues include storage space, setback space, accuracy of load indicators, pump pressure/volume capacity, and top drive output torque. Hole issues include hole cleaning, hole stability, hydraulics, casing wear, and directional objectives. (Judzis, et al., 1997)

The working relationship between various components of a drillstring must be carefully analyzed. Conventional drillstems are about 30 feet long and are made up of a bit, stabilizer, motor, a measurement-while-drilling (MWD) tool, drill collars, more stabilizers, and jars. There are more than 1,600 parts to a drillstring in a 24,000-foot well. A modern drillstring can be made up of hundreds of components from more than a dozen vendors. These components may not always perform as anticipated and may not meet operational demands of drilling an extended-reach well (JPT, 1994a).

Successful drilling and completion (casing and cementing) can be curtailed by factors both within and beyond human control. The best available technology may not be used or available due to the pressures of drill program scheduling and the lack of time devoted to seeking the most recent methods or tools. W. L. Penberthy, Jr., a wellbore construction adviser for Baker Hughes Inteq, notes that while the technology exists to complete wells without damaging them, some operators fail. Reasons for failure may include; the operator was in a hurry and didn't recognize that there was a problem; cost and logistical problems; or plans to have the proper fluid system in place in advance of drilling commencement were not made (JPT, 1994b)

ERD technology has been used instead of platform installation off California, where wells are drilled from onshore locations to reach offshore reserves. ERD has been instrumental in developing offshore reserves of the Sherwood reservoir under Poole Bay from shore at Wytch Farm, U.K. The original development plan called for the construction of a $260 million artificial island in the bay (JPT, 1994a). Other successes with ERD include the North Sea, Gulf of Mexico, South China Sea, and at Milne Point and Niakuk fields in Alaska (Judzis, et al., 1997).

A world record for an ERD well is a total horizontal departure of over 4 miles. While a 30,308 foot horizontal displacement was accomplished in 1997 at Phillips Xijiang 24-3 well in China (Phillips, 1997), horizontal displacements (departure from vertical) of one half mile to two miles are typical. In October of 1998, BP set a long-reach record for horizontal directional wells in the U.S. with a displacement of 19,804 ft. in the Niakuk Field (See Figure 6.1). Despite its $6 million price, the well represents a cost saving over the other drilling alternative—construction of an artificial gravel island (AJC, 1996a).

Although high departure ERD wells have been planned for some new platforms, the most common ERD applications are conceived after initial developments have been installed. This is due in part because drilling mechanics and performance are highly variable. Long departures show promise in applicability of ERD in Alaska, however equal consideration should be given to local ERD experience and rig capability in assessing the potential for ERD (Judzis, et al., 1997).

Current development wells in the Cook Inlet basin have been drilled with displacements in excess of 10,000 feet at total depth of approximately 10,000 feet vertical. In Cook Inlet, horizontal displacements of one-half mile to two miles are more typical (Schmidt, 1994).

## 2. History of Oil and Gas Exploration and Development

The Cook Inlet basin is a mature petroleum province in terms of exploration. The area of gas and oil discoveries in the upper Cook Inlet basin extends from the Kachemak Bay area north to the mouth of the Susitna River and includes fields in offshore Cook Inlet, the west shore of Cook Inlet and the western half of the Kenai Peninsula. The entire area covers approximately 4,400 square miles (KPB, 1990:1-22).

Exploration for oil in the Cook Inlet area began in the 1800's. Oil was reported on the west side of Cook Inlet in the vicinity of the Iniskin Peninsula by the Russians as early as 1853 (ADF&G, 1985b:869). In the early 1900's, Austin Lathrop drilled three wells on the west side of Cook Inlet. One was abandoned after a few hundred feet. The second well reached crude oil but encroaching water caused its abandonment. The third well was drilled but turned out to be unsuccessful (Berry, 1973:183).

Drilling continued sporadically in the first half of the century with little success. The end of World War II brought increased settlement to the Kenai Peninsula and the development of a road system. This inspired oilmen to study Alaska's resources again. In 1955, Richfield Oil Corporation began exploration on the Kenai Peninsula in the Swanson River area. Oil was discovered on July 23, 1957, at a depth of 11,000 feet and flowed at a rate of about 900 barrels a day (Berry, 1973:186)

Shortly after the Swanson River discovery, Standard Oil Company of California and Richfield formed a joint venture to explore for oil. Additional wells were drilled in the Swanson River area, and more leases were taken on both sides of Cook Inlet. Several other oil companies moved in to participate in drilling activities on the Kenai Peninsula (Berry, 1973:186). By 1959, 187,000 bbls of crude oil were produced annually. The state's competitive leasing process was instituted in 1959. In 1960, following further development of the Swanson River and Soldotna Creek Units, annual production rose to 600,000 bbls. Production peaked at 83 million bbls in 1970 and has declined to 12 million bbls in 1997 (ADNR 1998). Most of the larger oil fields were found by the mid-1960s.

"The first major gas discovery was made by the Union Oil Company of California and Ohio Oil Company in October 1959, with their Kenai Unit No. 14 in the Kalifonsky Beach [Kenai] gas field." (Berry, 1973:187) "Union-Ohio drilled three wells there in 1959 which had sufficient capacity to fulfill a twenty-year contract with Anchorage Natural Gas Corporation." (Berry, 1973:187). Gas production in Cook Inlet did not begin until 1960. By 1983, annual natural gas production had reached 196.4 billion cubic feet (Bcf); by 1992 annual production had fallen to approximately 125 Bcf (MMS, 1995: III.D.1). In 1997, Cook Inlet gas production was 12 thousand bbl of NGL's.

In 1962, Pan American Petroleum Corporation discovered the first offshore oil in Cook Inlet. This led to extensive exploration throughout the Cook Inlet region in the 1960s and 1970s. At the peak of its infrastructure development, there were 15 offshore production facilities in the Upper Cook Inlet (Berry, 1973:186).

The Cook Inlet region continues to be of interest to the petroleum industry. There are currently seven producing oil fields in the Cook Inlet basin. Reserves in these fields consist of about 76 million barrels of oil and 3 trillion cubic feet of natural gas (ADNR 1998).

In November 1993, ARCO and Phillips Petroleum announced an oil discovery at their Sunfish No. 1 well located about five miles east of Tyonek. The new Sunfish field was initially thought to hold 750 million bbls of oil. Subsequent delineation wells have generated disappointing results and reserve estimates are uncertain. In February 1998, Phillips Petroleum Company announced the results of a successful appraisal well in the Tyonek Deep oil play (formerly called Sunfish). Engineering studies have been initiated for pipelines and production facility design.

The Galena well in the Swanson River area, drilled by ARCO in 1991, was plugged and abandoned. The Westfork well in the Swanson River area was farmed out to and recently drilled by Cook Inlet Region, Inc. which reported commercial quantities of gas. Chevron completed its Kustatan No. 1 exploratory well near West Forelands in January of 1992. The well was plugged and abandoned (ADNR 1993). ARCO has also plugged and abandoned an exploratory well, the BLT No. 1, at Big Lake in the Wasilla area.

The Tyonek area has been the focus of gas exploration since 1965 when the Moquawkie Indian Reservation sold oil and gas rights to its lands. Numerous exploratory wells have been drilled near Tyonek and two gas fields, the Albert Kaloa and Moquawkie, were discovered (ADNR: 1993).

Existing Cook Inlet oil production is handled through the Trading Bay production facility, the Tesoro Refinery, the Phillips-Marathon LNG (liquefied natural gas) plant, and the Union Chemical plant. The last three facilities are located at Nikiski. The Trading Bay facility pipelines crude oil production it receives to the Drift River Terminal. The Drift River Terminal stores and loads at least 9 million bbls annually. Almost all of the Drift River crude is transported to the oil refinery in Nikiski.

The Tesoro Refinery normally processes up to 55,000 bbl per day. Recent refinery production has been augmented by North Slope oil transported by tanker from Valdez. All of the Tesoro refinery output is consumed within Alaska. A products pipeline links the Nikiski refinery with the Tesoro fuel depot located at the Port of Anchorage. Tesoro's refined products include multigrades of gasoline, propane, Jet A, Diesel, No. 2 Diesel, JP4, and No. 6 fuel oil (MMS, 1995: III.D.1).

The Phillips-Marathon LNG plant was constructed in 1969 and liquefies 1 million tons of LNG annually. It is the United States' only natural gas liquefaction plant. Produced LNG is shipped by tanker to Japan by 80,000 cubic meter carriers on an average of once every 10 days (MMS, 1995: III.D.1).

Natural Gas produced from the Kenai Gas Field is transported by pipeline to Anchorage and Girdwood for domestic consumption. Gas produced from the Beluga River field is used on-site at the Beluga River power plant and is transported by pipeline to Anchorage for domestic consumption (MMS, 1995: III.D.1). Enstar Natural Gas Company has expanded its distribution system to encompass Palmer and Houston.

The Union Chemical company plant can process gas to produce more than 1.1 million tons of ammonia and a similar quantity of urea pills and granules (for fertilizer). Some of the produced urea is used in Alaska; the rest is shipped to the U.S. West Coast in tankers and bulk freighters (MMS, 1995: III.D.1).

The lower portion of the sale area (south of Soldotna) lacks the oil and gas infrastructure of upper Cook Inlet (Figure 6.5, Infrastructure map). Exploration and development would require construction of onshore drilling pads and possibly offshore platforms. A commercial discovery in this part of the sale area would require the construction of pipelines to connect with existing facilities. Some new roads may also be required (See discussion of transportation methods in Chapter Five).

Over 5.6 million acres of state land have been leased in 40 state oil and gas lease sales in the Cook Inlet region since 1959 (Table 6.3). Some of this acreage has been leased more than once because some leases had previously expired or were relinquished. As of December 2, 1998, 734,772 acres are under lease in Cook Inlet (offshore acreage totals 340,230 acres and onshore acreage totals 394.542 acres) (ADNR, 1998).

Ninety-seven percent of the land offered in this sale has been offered before. As of March 1998, 5,474 tracts of state land had been offered for lease in Cook Inlet, of which, 2,878 (52.6 percent) had been leased. In terms of acres, 13,104,665 acres had been offered and 5,624,967 (42.9 percent) were leased. For federal lease sales, about one in four tracts or acres offered has been leased. The total number of tracts leased in Cook Inlet for both state and federal sales was 2,926 as of March 1998. Total acres offered and leased are depicted in Figure 6.6.

Exploratory drilling was conducted on just 8.5 percent of these tracts. Of the 261 exploration wells drilled as of year-end 1996, only 24 discoveries have been made for a success ratio of 9.2 percent. Only 18 of these discoveries are currently producing, yielding a production success rate for exploratory wells in Cook Inlet of 6.9 percent. As indicated in Figure 6.7, exploration well drilling peaked in the late 1960's.

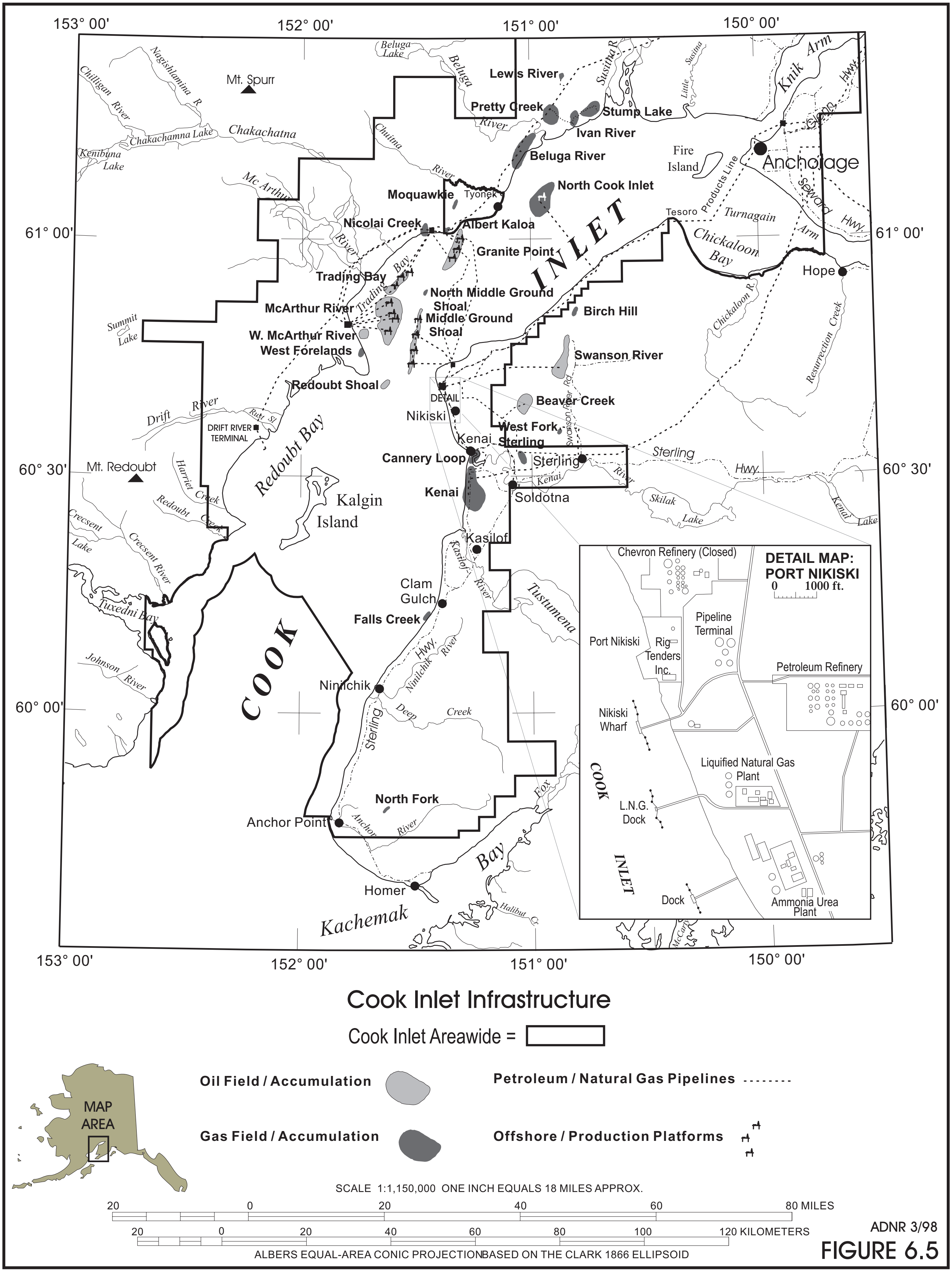
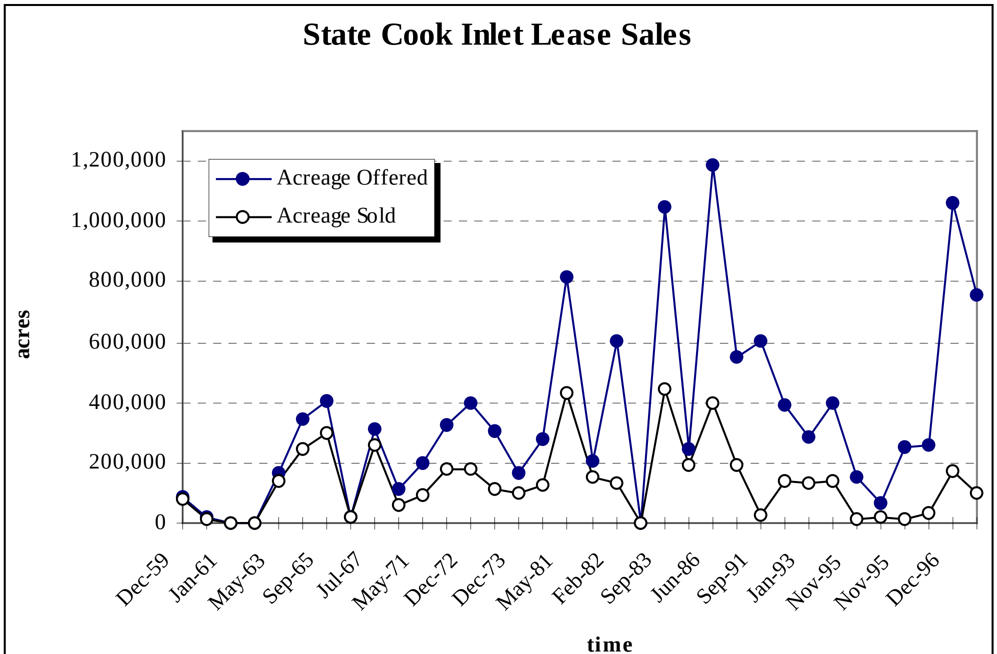

153° 00'
152° 00'
151° 00'
150° 00'
61° 00'
60° 30'
60° 00'
Mt. Spurr
Mt. Redoubt
Lewis River
Pretty Creek
Stump Lake
Ivan River
Beluga River
North Cook Inlet
Moquawkie
Tyonek
Nicolai Creek
Albert Kaloa
Granite Point
Trading Bay
North Middle Ground Shoal
Middle Ground Shoal
McArthur River
W. McArthur River
West Forelands
Redoubt Shoal
Birch Hill
Swanson River
Beaver Creek
West Fork
Sterling
Cannery Loop
Kenai
Falls Creek
North Fork
DETAIL
Nikiski
Kenai
Soldotna
Kasilof
Clam Gulch
Ninilchik
Anchor Point
Homer
Hope
Anchorage
Fire Island
Tesoro
Products Line
DRIFT RIVER TERMINAL
Kalgin Island
Redoubt Bay
Tuxedni Bay
Chickaloon Bay
Turnagain Arm
Knik Arm
Kachemak Bay
INLET
COOK
Beluga Lake
Chakachamna Lake
Kenibuna Lake
Summit Lake
Skilak Lake
Tustumena
DETAIL MAP: PORT NIKISKI
0 1000 ft.
Chevron Refinery (Closed)
Pipeline Terminal
Port Nikiski
Rig Tenders Inc.
Petroleum Refinery
Nikiski Wharf
Liquified Natural Gas Plant
L.N.G. Dock
Dock
Ammonia Urea Plant
COOK INLET
Cook Inlet Infrastructure
Cook Inlet Areawide =
Oil Field / Accumulation
Gas Field / Accumulation
Petroleum / Natural Gas Pipelines
Offshore / Production Platforms
MAP AREA
SCALE 1:1,150,000 ONE INCH EQUALS 18 MILES APPROX.
20 0 20 40 60 80 MILES
20 0 20 40 60 80 100 120 KILOMETERS
ALBERS EQUAL-AREA CONIC PROJECTION BASED ON THE CLARK 1866 ELLIPSOID
ADNR 3/98
FIGURE 6.5

**Figure 6.6 Cook Inlet State Oil and Gas Lease Sales**



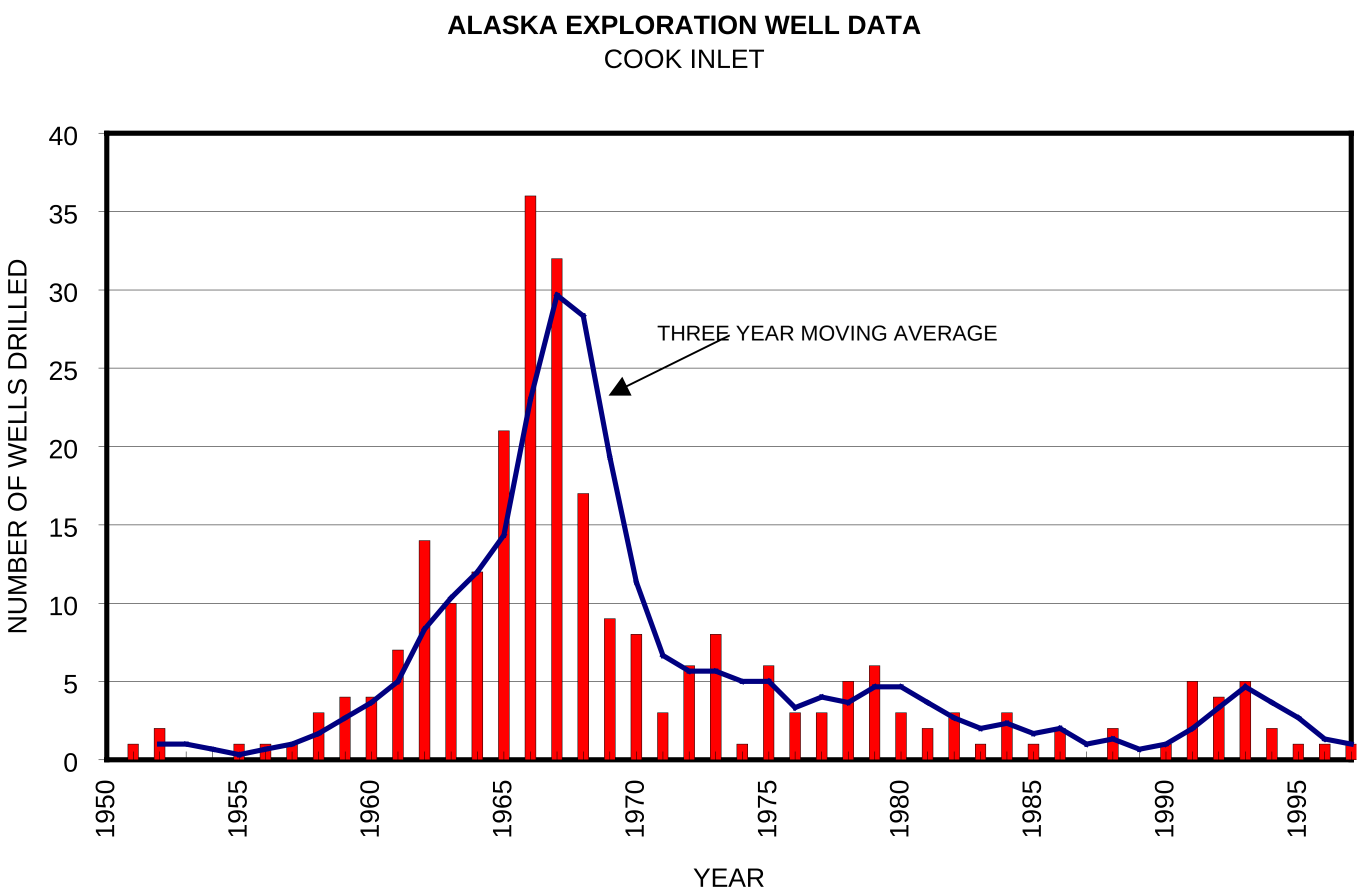

Source: ADNR, 1/97; Kornbrath, 1995.

Table 6.3 Cook Inlet Acreage Leased

| Sale | Areas Leased | Year | Acreage Sold |
|---|---|---|---|
| 1 | Wide Bay; offshore Kenai to Ninilchik; Kachemak Bay | 1959 | 77,191.00 |
| 2 | Kenai Peninsula; West Forelands; Nushagak Bay | 1960 | 16,505.57 |
| 3 | Katalla; Kalifonsky Beach; Herendeen Bay; offshore Kodiak | 1960 | 22,866.70 |
| 4 | Uplands Ninilchik | 1961 | 400.00 |
| 5 | Tyonek; Controller Bay; Pavlov Bay | 1961 | 95,980.00 |
| 6 | Controller Bay (Special Sale) | 1961 | 13,257.00 |
| 7 | Icy, Yakutat & Kachemak Bays; S. Kenai Peninsula; N. Cook Inlet | 1961 | 187,025.40 |
| 8 | Big Lake | 1962 | 1,061.70 |
| 9 | Tyonek; W. Forelands; Knik Arm/Kalgin Isl.; Chisik Isl.; S. Kenai Penin.; Wide Bay | 1962 | 264,437.13 |
| 10 | Tyonek; Kenai Offshore & Uplands | 1963 | 141,490.51 |
| 12 | S. of Forelands; Knik & Turnagain Arms; Upper Cook Inlet; Kenai Peninsula; Tyonek to Katunu River | 1963 | 247,089.00 |
| 13 | Fire Isl.; W. Forelands; Trinity Isl. | 1964 | 149,089.00 |
| 15 | Fire Isl. & N. Cook Inlet; Kalgin Isl. & Redoubt Bay; Knik; S. Kenai Penin | 1965 | 301,751.28 |
| 16 | Kenai Peninsula. & Knik; Middleton Isl.; Fire Isl., Redoubt Bay; Kalgin Isl.; Iliamna Vol.; N. Cook Inlet | 1966 | 133,987.29 |
| 17 | Big Lake; Kenai | 1966 | 18,589.70 |
| 20. | Big Lake; Knik; Iliamna Vol.; Beluga; N. Cook Inlet; Kalgin Isl.; Ninilchik | 1967 | 256,447.31 |
| 22 | Big Lake; Knik; Beluga; W. Forelands; Ninilchik; Kachemak & Kenai | 1968 | 60,272.15 |
| 24 | Big Lake; Knik; Kenai; W. Forelands | 1969 | 92,617.97 |
| 25 | Big Lake; Knik; Beluga; N. Cook Inlet | 1972 | 178,244.71 |
| 26 | Cook Inlet | 1972 | 177,972.56 |
| 27 | Tuxedni; Ninilchik; Kenai; Kalgin | 1973 | 113,891.71 |
| 28 | Ninilchik; Kachemak Bay; Beluga | 1973 | 97,803.69 |
| 29 | Kalgin & W. Forelands; Chisik; Ninilchik; N. Cook Inlet; Turnagain; Big Lake | 1974 | 127,119.65 |
| 33 | Upper Cook Inlet | 1981 | 429,978.16 |
| 32 | Lower Cook Inlet | 1981 | 152,428.22 |
| 35 | Lower Cook Inlet | 1982 | 131,190.69 |
| 37A | Chakok River, Exempt | 1982 | 1,874.60 |
| 40 | Upper Cook Inlet | 1983 | 443,354.88 |

| Sale | Areas Leased | Year | Acreage Sold |
|---|---|---|---|
| 46A | Cook Inlet Exempt | 1985 | 190,041.54 |
| 49 | Cook Inlet | 1986 | 394,880.74 |
| 67A | Cook Inlet Exempt | 1991 | 191,588.06 |
| 74 | Cook Inlet | 1991 | 26,604.99 |
| 67AW | Cook Inlet | 1993 | 129,809.68 |
| 76 | Cook Inlet | 1993 | 141,503.66 |
| 78 | Cook Inlet | 1994 | 136,306.63 |
| 67AW2 | Cook Inlet Exempt | 1995 | 13,804.36 |
| 74W | Cook Inlet Exempt | 1995 | 17,015.32 |
| 76W | Cook Inlet Exempt | 1995 | 141,503.66 |
| 78W | Cook Inlet Exempt | 1995 | 36,477.72 |
| 85A | Cook Inlet Exempt | 1996 | 173,502.92 |
| 85A-W | Cook Inlet Exempt | 1998 | 98,010.77 |
| | **Total** | | **5,624,967.63** |

**Figure 6.7 Cook Inlet Exploration Well Drilling**

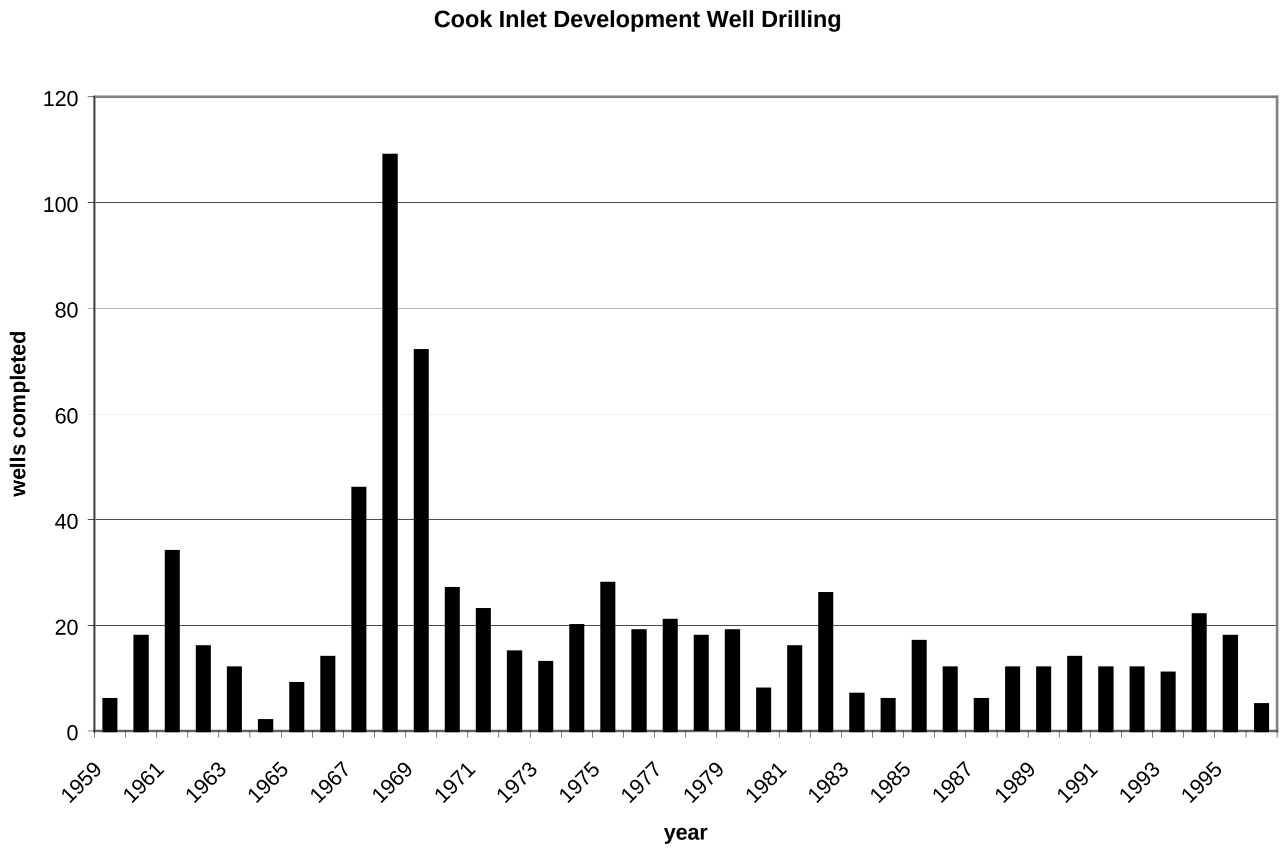



Oilfield development peaked in the region in the 1970's. Existing industrial users, like the Tesoro refinery, Unocal's urea and ammonia plant, and Phillips' LNG plant, and Enstar will need oil and gas to meet future energy and processing needs. As a result, the incentive to explore has increased in recent years.

Companies are aggressively looking for reserves to replace declining fields. Advances in seismic technology have also increased interest in exploration in Cook Inlet. New 3-D seismic profiling may identify previously hidden accumulations within existing fields. Smaller accumulations, once uneconomic to produce, are being developed at the fringes of existing infrastructure. Exploration in the northern portion of the Cook Inlet basin and to the south of fields on the Kenai Peninsula may reveal developable prospects. New independent companies are being attracted to Alaska. In the near-term, Miami-based Forcenergy hopes to drill a gas exploration well west of the Pretty Creek field on the west side on CIRI land. Forcenergy also has plans to drill the Boulder Shoal prospect adjacent to West McArthur River Unit. Frontier Petroleum also has plans for a gas exploration well west of Trading Bay Field. Anadarko drilled a well and discovered gas near Tyonek on Moquawkie lands. Phillips plans more drilling for the Tyonek Deep accumulation (formerly called Sunfish). CIRI also has considerable subsurface mineral interests in the region and has plans for exploration and development of those resources.

As indicated in Figure 6.8, development and production well drilling peaked in the late 1960's. In 1996, the North Middle Ground Shoal Unit was established. The Redoubt Unit was established in 1997 with Forcenergy as operator.

**Figure 6.8 Cook Inlet Development Well Drilling**




Existing developed and undeveloped accumulations in Cook Inlet are presented in Table 6.4. Ninety-seven percent of discovered accumulations are currently developed or under development.

For a description of current petroleum industry and support service industry activities, and information on natural gas demand, see Chapter Four.

Table 6.4 Cook Inlet Oil and Gas Accumulations

| Accumulation | Remaining Reserves | | Percent depleted | |
|---|---|---|---|---|
| | Oil (million barrels) | Gas (billion cubic feet) | Oil | Gas |
| **Developed or Under development** | | | | |
| Beaver Creek | 1 | 104 | 84% | 56% |
| Beluga River | - | 669 | - | 46% |
| Cannery Loop | - | 33 | - | 70% |
| Granite Point | 12 | 24 | 92% | 81% |
| Ivan River, Lewis River, Pretty Creek, Stump Lake | - | 48 | - | 49% |
| Kenai | - | 283 | - | 88% |
| McArthur River | 22 | 525 | 96% | 59% |
| Middle Ground Shoal | 9 | 13 | 95% | 88% |
| North Cook Inlet | - | 1,023 | - | 55% |
| North Trading Bay | - | 20 | - | 17% |
| Sterling | - | 23 | - | 10% |
| Swanson River | 3 | 182 | 99% | 0% |
| Trading Bay | 3 | 28 | 97% | 71% |
| West Fork | - | 3 | - | 58% |
| West McArthur River | 1 | - | 80% | - |
| **Undeveloped** | | | | |
| Birch Hill | - | 11 | - | - |
| Falls Creek | - | 13 | - | - |
| Nicolai Creek | - | 2 | - | - |
| North Fork | - | 12 | - | - |
| Tyonek Deep (Sunfish) | 25 | 30 | - | - |
| West Foreland | - | 20 | - | - |
| Redoubt Shoal | | | - | - |
| **TOTAL** | 76 | 3,066 | | |

source: Beasley, 1998

# B. Effects on fish & wildlife habitat and populations

The potential negative impacts of industry's activities in the Cook Inlet and Susitna areas include potential loss of fish and wildlife habitat; environmental degradation; and restriction of access for commercial and subsistence uses, fishing and hunting. Potential positive effects include increased understanding of the environment, protection of existing habitat and wildlife values, habitat restoration and enhancement, and infrastructure to support continued use of local resources.

## 1. Effects on Water, Air, and Land resources

General effects on water, air, and land are described below. For more detail on effects on water quality, see Chapter Five.

### a. Effects on water quality

Cumulative effects on sale area water quality are discussed in Chapter Five.

### b. Effects on air quality

Air quality throughout the Cook Inlet and Susitna areas is very good, with concentrations of regulated pollutants well below the maximum allowed under National Ambient Air Quality Standards in Cook Inlet. In order to ensure that air quality standards are maintained, additional limitations on nitrogen dioxide, sulfur dioxide, and total-suspended-particulate matter are imposed on industrial sources under the provisions of the Prevention of Significant Deterioration Program, administered by EPA (ADEC, 1997) (EPA, 1997).

Routine activities associated with oil and gas exploration, development and production that are likely to affect air quality are emissions from construction, drilling and production. Air pollutants include nitrogen oxides ($NO_X$), carbon monoxide (CO), sulfur dioxide ($SO_2$), particulate matter (PM), and volatile organic compounds[1] (VOC) (MMS, 1995, IV.B.1-92). Effects from VOC emissions would be insignificant because of the low potential for ozone formation. Photochemical pollutants such as ozone ($0_3$) form in the air from the interaction of pollutants in the presence of sunshine and heat. In the upper atmosphere ozone is beneficial because it absorbs solar ultraviolet radiation. In the lower atmosphere however, it is a strong oxidizing agent and can be harmful. There is a low potential for ozone formation in the sale area because the summertime air temperatures remain relatively low (MMS, 1996, IV.B.1-94).

Trucks, heavy construction equipment and earth moving equipment would produce emissions, such as engine exhaust and dust. Sources of air emissions during drilling operations include rig engines, camp generator engines, steam generators, waste oil burners, hot-air heaters, incinerators, and well test flaring equipment. Emissions would also be generated during installation of pipelines and utility lines, excavation and transportation of gravel, mobilization and demobilization of drill rigs, and during construction of gravel pads, roads, and support facilities. Elevated levels of airborne emissions would be temporary and would diminish after construction phases are complete. Emissions would also be produced by engines or turbines used to provide power for drilling, oil pumping, and water injection. In addition, aircraft, supply boats, personnel carriers, mobile support modules, as well as intermittent operations such as mud degassing and well testing would produce emissions (MMS, 1996, IV.B.1-93).

Other sources of air pollution include evaporative losses (VOC) from oil/water separators, pump and compressor seals, valves and storage tanks. Venting and flaring could be an intermittent source of VOC and $SO_2$ (MMS, 1995, IV.B.1-93). Gas blowouts, evaporation of spilled oil and burning of spilled oil may also affect air quality. Gas or oil blowouts may catch fire. A light, short-term coating of soot over a localized area could result from oil fires. However, soot produced from burning oil spills tends to slump and wash off vegetation in subsequent rains, limiting any health effects (MMS, 1995, IV.B.1-95).

During tanker loading operations at the Nikiski and Drift River terminals, emissions would result from the tanker-exhaust stacks and fugitive losses. Additional VOC emissions would result from storage of crude oil at the Nikiski and Drift River terminals. VOC emissions would be reduced with vapor recovery during operations. To operate oil storage and transfer facilities, the operators would be required to provide air quality analysis and to obtain permits, which meet state and federal ambient air quality standards. Effects analyses and permit approval are done at the project level when proposed emissions can be quantified (MMS, 1995:IV.B.1-89).

ADEC's Air Quality Maintenance program controls significant, stationary sources of air contaminants to protect and enhance air quality and abate impacts on public health and the environment. The 1970 Clean Air

[1] Volatile organic compounds are any hydrocarbon that can become a vapor at room temperature.

Act established air quality programs to regulate air emissions from stationary, mobile and other sources, which pose a risk to human health and the environment. ADEC monitors compliance with regulations and air quality standards through annual inspections and uniform enforcement procedures. The agency issues operating permits to existing major facilities incorporating all applicable requirements, and issues construction permits to new large facilities and for expansions of existing facilities (ADEC, 1997).

It is not possible to predict at the lease sale stage the amount of pollutants that may be produced. All industrial emissions must comply with the Clean Air Act (42 U.S.C. §§ 7401-7642) and state air quality standards. 18 AAC 50 provides for air quality control including permit requirements, permit review criteria, and regulation compliance criteria. 18 AAC 50.300 sets up standards for air quality at certain facilities, including oil and gas facilities, at the time of construction, operation, or modification. Federal and state statutes and regulations that will mitigate potential impacts to air quality include:

- 42 U.S.C. §§ 7401-7671. Federal Clean Air Act
- AS 46.03. Provides for environmental conservation including water and air pollution control, radiation and hazardous waste protection.
- 18 AAC 50. Provides for air quality control including permit requirements, permit review criteria, and regulation compliance criteria.
- 18 AAC 50.300. Sets up standards for air quality at certain facilities including oil and gas facilities at the time of construction, operation, or modification.

### c. Effects on land habitat

Seismic surveys. Seismic surveys are usually conducted in winter to minimize impacts to the environment, fish and wildlife and their habitats, and on people. In the past, surveyors required long clear-cuts for line-of-sight measurements. That practice left distinct lines, which crisscross the forests of the Kenai Peninsula and the Susitna Valley. Modern seismic surveys use global satellite positioning instruments and tree cutting is no longer necessary. Recent seismic surveys conducted on the Kenai Peninsula employed small helicopters and lightweight gear to lessen disturbance. Soil is disturbed in the immediate vicinity of the explosive charges placed into the ground. To avoid undesirable effects on shallow wells and nearby building foundations, hydraulic devices are used in lieu of explosives to produce the seismic wave energy. See Chapter Five for discussion on effects on water quality.

Drilling and Production Discharges. During exploration well drilling, muds and cuttings are stored on-pad, in holding tanks, or in a temporary reserve pit, and then hauled to an approved solid waste disposal site or reinjected into the subsurface at an approved injection well. Muds and cuttings are either treated on-site and disposed at an approved facility, or shipped to a disposal facility out-of-state.

Effects of Construction and Gravel Infilling. Effects of constructing production pads, roads, and pipelines include direct loss of acreage due to gravel infilling, and due to impoundment and diversion of water. A secondary effect of construction activities includes dust deposition, which may reduce photosynthesis and plant growth, and downstream siltation and sedimentation, which can affect plant viability. Road construction, vehicular passage, and oil spills can alter surface albedo (reflectivity of sunlight off the earth's surface) or water drainage patterns, resulting in thaw and subsidence or inundation. Such changes can affect regeneration and revegetation of certain species, and species composition may also change after disturbance from construction activities (Linkins, et al., 1984).

After an oil field is abandoned, some level of land rehabilitation will be required to restore areas impacted by oil and gas activities. Recovery of wetlands disturbed by gravel infilling varies depending on soil moisture content and amount of available soil organic matter (Kidd, et al., 1997, citing to Jorgenson and Joyce, 1994). Removal of gravel from pads and roads is the initial step in rehabilitation. One method preferred by

ADF&G is to remove all gravel and create pond habitat that resembles pre-construction conditions. In some cases, full gravel removal may not be the optimum recovery option. In most cases, plant cultivation is desirable with the use of plant species identified as important for waterbird or moose habitat. While rehabilitation methods for gravel pad and roads vary depending on site-specific conditions, the overall goal of rehabilitation in the existing oil fields is to replace native vegetation. Plant cultivation treatments include fertilizer only, native-grass cultivation, and transplantation of desired species. Optimum recovery of the land habitat would include reestablishing vegetable, soil microbiotic, phytoplankton, aquatic invertebrate, and wildlife communities at the impacted site (Kidd, et al., 1997).

Gas Blowouts**.** If a natural gas blowout occurred, plants in the immediate vicinity may be destroyed. Natural gas and condensates that did not burn in the blowout would be hazardous to any organisms exposed to high concentrations. Insects, such as mosquitoes, would also be affected or killed by a gas blowout. A plume of natural gas vapors and condensates would be dispersed very rapidly from the blowout site, but is not expected to be hazardous for more than one kilometer downwind or for more than one day. Natural gas development is expected to have little to no effect on lower trophic-level organisms (MMS, 1996b: IV-L-2).

Oil Spills**.** Spilled oil will affect vegetation depending on time of year, type of vegetation, and terrain. Spilled oil will migrate both horizontally and vertically. This flow depends on factors including the volume spilled, type of cover (plant or snow), slope, presence of cracks or troughs, moisture content of soil, temperature, wind direction and velocity, thickness of the oil, discharge point, and ability of the ground to absorb the oil (Linkins, et al., 1984). The spread of oil is less when it is thicker, cooler, or is exposed to chemical weathering. If the ground temperature is less than the pour point of the oil, it will pool and be easier to contain. Dry soils have greater porosity and the potential for vertical movement is greater (Linkins, et al., 1984, citing to Everett, 1978). If oil penetrates the soil layers and remains in the plant root zone, longer-term effects, such as mortality or reduced regeneration would occur in following summers. Under the right conditions involving oxygen, temperature, moisture in the soil, and the composition of the crude being spilled, bacteria assist in the breakdown of hydrocarbons in soils. Petroleum-contaminated soils are commonly treated with fertilization, raking, and tilling (bioremediation). Research is ongoing in the use of microbes to assist the natural break down of petroleum in soils and gravel (Linkins, et al., 1984) (AJC, 1996).

### Mitigation Measures and Lessee Advisories.

The following are summaries of some applicable mitigation measures and lessee advisories that would mitigate potential impacts to land habitat. For a complete, full text listing of mitigation measures see Chapter Nine.

- Wetland protection -- Lessees must avoid siting facilities in key wetlands and identified sensitive habitat areas.
- Habitat loss minimization -- Exploration facilities must not be constructed of gravel. Ice roads and pads are preferred structures. Gravel mining is restricted to the minimum necessary to develop the field efficiently.
- Drilling waste -- Underground injection of drilling muds and cuttings is preferred method of disposal. For onshore development, produced waters must be injected. Surface discharge of drilling wastes into waterbodies and wetlands is prohibited. Discharge of produced waters into open or ice-covered marine waters of less than 10 m in depth is prohibited.
- Oil Spill Prevention and Control -- Lessees are advised they must prepare contingency plans addressing prevention, detection, and cleanup of oil spills. Pipelines must be designed and located to facilitate cleanup.
- Rehabilitation -- At the option of the state, all improvements such as roads, pads, and wells must be either abandoned and the sites rehabilitated by the lessee, or left intact. Any machinery, equipment, tools or

materials left behind after the lease is terminated become the property of the state, and may be removed by the state at the lessee's expense.

- No Surface Entry -- Surface entry is prohibited within the Palmer Hay Flats SGR, Anchorage Coastal Wildlife Refuge, Clam Gulch CHA, Anchor River and Fritz creek CHA, within core Tule goose and trumpeter swan nesting and molting corridors in the Trading Bay SGR and CHA, in the Goose Bay SGR, Kalgin Island CHA, Kasilof River critical waterfowl habitat, caribou core calving areas, and within an area along the Kenai River.

## 2. Effects on Lower Trophic Levels

Drilling and Production Discharges. The types of discharges resulting from oil and gas activities include drilling muds and cuttings, and formation waters. The discharge of drilling muds and cuttings creates plumes of material that disperse rapidly in the water column. Impacts of drilling fluid and cuttings on the benthos is directly related to the amount of material accumulating on the substrate, which in turn is related to the amount and physical characteristics of the materials being discharged, and to the environmental conditions at the time and site of discharge, such as current speed and water depth. In high-energy environments, mud and cuttings accumulate less and impacts on the benthos are minimal and of short duration. In low-energy and depositional environments, more material accumulates and there may be reductions in abundance of some benthic species (Neff, 1987).

Produced waters represent the largest source of discharge by volume with respect to offshore oil and gas operations. When discharged, toxicity of produced waters ranges from slightly toxic to practically non-toxic. Toxicity decreases with continued mixing in the water column (MMS, 1995, IV. B.1-17). For more detail on impacts to marine water quality, see Chapter Five.

Seismic surveys. Seismic surveys are expected to have little or no effect on plankton because airguns (the acoustic-energy sources now commonly used), do not appear to have any adverse effect on this group of organisms (MMS, 1996: IV.B.1.1-18). Use of explosive charges in seismic data acquisition produces lethal effects on lower level organisms in the immediate vicinity of the blast, however no adverse cumulative effect on organic production is anticipated.

Facility Construction. A small area would be affected by oil and gas pad, platform, and pipeline construction relative to total available habitat. Most lower trophic-level organisms would be displaced by pad construction. Groundbreaking and disturbance of vegetation may increase biological activity. Offshore platforms provide additional habitat for invertebrates and marine plants that require a hard, secure substrate for settlement. Less mobile organisms that rely on soft substrates such as bivalves and polychaetes would be adversely affected if their habitat is altered or eliminated by platforms or pipeline construction. The more mobile adult invertebrates are expected to avoid these areas of disturbance and should not be affected (MMS, 1995, IV.B.1-21).

Gas Blowouts. If a natural gas blowout occurred, marine plants and invertebrates in the immediate vicinity might be killed. Natural gas and condensates that did not burn in the blowout would be hazardous to any organisms exposed to high concentrations. A plume of natural gas vapors and condensates would be dispersed very rapidly from the blowout site, but it is not expected to be hazardous for more than one km downwind or for more than one day (MMS, 1996: IV.F.2).

Oil Spills. Petroleum hydrocarbons can have immediate and marked effects on the rate of photosynthesis of natural phytoplankton assemblages. A wide range of petroleum hydrocarbons depresses growth of phytoplankton and photosynthesis. If a large number of phytoplankton were affected by an oil spill, regeneration time of the cells (9-12 hours), together with the rapid replacement by phytoplankton from adjacent waters would prevent any major, long term impact on a pelagic phytoplankton community (NRC, 1985).

Studies in Prince William Sound indicate that zooplankton play a major role in food chains that support pink salmon and probably herring. Macrozooplankton may also be much more important as a forage resource for other fishes, marine mammals and birds (Cooney, 1994). Field observations of zooplankton at oil spills and in chronically polluted areas have shown that zooplankton were affected but that these effects appeared to be short lived. Individual zooplankton within chronically polluted areas have experienced direct mortality due to external contamination by oil, tissue contamination, inhibition of feeding, and altered metabolic rates. However, because of their wide distribution, large numbers, and rapid rate of regeneration, zooplankton communities exposed to oil spills in open-water areas are expected to recover in one week. In areas where flushing rates and water circulation are reduced, the effects of an oil spill are expected to be greater, and recovery of zooplankton are expected to take one to two weeks (NRC, 1985). Claanoid coepods have a very slow reproduction rate and would be replaced by currents sweeping new copeods into Cook Inlet rather than recovery by reproduction. This may take several weeks (ADF&G, 1998:2-3).

What is known about the effect of crude oil on marine plants has come largely from observations following oil spills. Both lethal and sub-lethal effects have been observed. Effects vary considerably depending on plant species, type and concentration of oil, and the timing and duration of exposure. Following the *Exxon Valdez* oil spill (EVOS), the recolonization of heavily oiled intertidal rocky habitat began the first year after the spill. In the lower and middle intertidal zones, injured populations of the brown seaweed *Fucus* appear to have recovered, but recovery has been much slower in the upper intertidal (EVOSTC, 1995:17). On the sheltered bedrock shores that are common in Prince William Sound, full recovery of *Fucus* is crucial for the recovery of intertidal communities at these sites, since many invertebrate organisms depend on the cover provided by this seaweed. *Fucus* has not yet fully recovered in the upper intertidal zone on shores subjected to direct sunlight, but in many locations, recovery of intertidal communities has made substantial progress (EVOSTC, 1996:9). *Fucus* colonies destroyed by the *Exxon Valdez*, often appear to have been restored when a single year class of *Fucus* germlings covered previously denuded substrate. These colonies were sometimes so dense that germlings in later years could not start beneath them. Subsequently these original re-colonizers all senesced about the same time and died, leaving the substrate once again bare. *Fucus* will have actually recovered when any given colony contains several year classes of plants (ADF&G, 1998:2-3)

Oil from the EVOS that was transported down to subtidal habitats caused changes in the abundance and composition of plant and animal populations below lower tides. The greatest differences were detected at oiled sites with sandy sea bottoms in the vicinity of eelgrass beds, where there was reduced abundance of eelgrass shoots and flowers (EVOSTC, 1996:17). Following the EVOS, eelgrass shoot and flower densities were reported to be lower at oiled sites for up to two years (Dean, et al. 1993). Reproductive potential of eelgrass beds appeared to be reduced offshore of oiled intertidal sites (Houghton et al. 1991).

Crude oil can have lethal effects on marine invertebrates depending on the volume of oil and the length of the exposure. Sub-lethal effects on crustaceans include failure to molt, swim, feed, or reproduce, and inhibited growth. Oil has been shown to interfere with chemoreception, which is used by many invertebrates to find their prey (NRC, 1985).

Marine invertebrates inhabiting the intertidal zone such as clams, mussels, worms, juvenile crab, barnacles, limpets, and echinoderms also are likely to be contacted by an oil spill. The EVOS and subsequent cleanup activities had significant effects on the animals and plants that live in the intertidal zone (EVOSTC, 1996). Impacts to intertidal organisms occurred at all tidal levels in all types of habitats throughout the oil-spill area. Many species of algae and invertebrates were less abundant at oiled sites compared to un-oiled reference sites (EVOSTC, 1996:9). In oiled coastal areas of western Prince William Sound and the nearby Gulf, intertidal organisms died due to smothering and the acute toxicity of the oil (EVOSTC, 1989). Exposed intertidal areas are quicker to recover from the effects of an oil spill due to higher rates of flushing. Protected intertidal areas are expected to take longer to recover. In estuaries and cobble beaches, many species of invertebrates did not show signs of recovery when they were last surveyed in 1991 (EVOSTC, 1996:9).

**Mitigation measures:**

The following are summaries of some applicable mitigation measures that would mitigate potential impacts lower trophic levels. For a complete, full text listing of mitigation measures, see Chapter Nine.

- Protection from drilling and production discharges -- lessees must use appropriate methods for disposal of muds, cuttings, and produced waters.
- Surface entry into the Clam Gulch CHA is prohibited
- Lessees are prohibited from using explosives with a velocity of greater than 3,000 feet per second in marine waters.
- Oil spill prevention and control -- lessees must prepare contingency plans addressing prevention, detection, and cleanup of oil spills. Lining, diking and buffer zones are required to separate oil storage facilities from marine and freshwater supplies.

## 3. Effects on Fish

Several species of anadromous fish spawn and overwinter in the rivers within the Cook Inlet/Susitna areas and during summer migrate to nearshore coastal waters to feed. Migration patterns vary by species and within species by life stage. Potential impacts in the exploration phase include degradation of stream banks and overwintering areas at stream crossings. Potential impacts in later phases include habitat loss due to gravel removal and facility siting, and fish kills due to oil spills and seismic activities (ADNR, 1995:59).

Drilling and Production Discharges. Marine disposal of drilling muds, cuttings, and produced waters may have a potential toxic effect on organisms, however within a distance of between 100 and 200 m from the discharge point, the discharged muds and cuttings are expected to be diluted to levels that are within the range associated with naturally occurring concentrations (MMS, 1995: IV.B.1-8). If fish are present at the time of discharge, it is probable that they would be disturbed and displaced from the immediate vicinity of the discharge, within a radius probably not to exceed 100 m depending on factors such as water depth and currents. The effects would be limited to only the short time periods when materials are being discharged (MMS, 1995: IV.B.1-32).

Habitat loss (degradation of stream bank and overwintering areas). Protecting the integrity of stream bank vegetation and minimizing erosion are important elements in preserving fish habitat. Streambeds could be affected by altering stream banks and by equipment crossings (ADNR, 1995:59).

During development, unregulated gravel removal from fishbearing streams to support oil and gas activities could adversely impact these streams and the fish they support. Gravel removal could increase sediment loads, change the stream bed course, cause instability upstream, destroy spawning habitat, and create obstacles to fish migration. (ADNR, 1995:59).

Seismic activities. Generally airguns can disturb and displace fishes and interrupt feeding in the immediate vicinity of the activity. There is also some evidence that seismic activities from airguns can damage eggs and larvae of some fish. This injury apparently is limited to within a meter or two from the airgun. Given the relative low densities and wide distribution of eggs and larvae in Cook Inlet, it is not likely that any large numbers of eggs or larvae would be subjected to this hazard. Thus, it is unlikely that seismic surveys would have any appreciable adverse effects on fishes in the marine environment. These effects are considered to be limited in area and time and, therefore, without significance to local fish populations (MMS, 1995: IV.B.1-33). Larval and juvenile fish often occur in schools and would be more at risk (ADF&G, 1998:3-3).

Onshore seismic operations could cause direct injury to fish resources in lakes and streams (Fink, 1996 citing to Linton et, al., 1985). Pressure waves from high explosives such as ammonia nitrate will kill and injure fish, near the explosion (Fink, 1996 citing to Trasky, 1976; Falk and Lawrence, 1973; Hill, 1978). Overpressures of 30-40 psi will kill fish with swim bladders, and 3-4 psi will kill juvenile salmonids. Shock waves from explosions can also shock and jar fish eggs at sensitive stages of development (Fink, 1996, citing to Trasky, 1976; Linton et. al., 1985).

These types of impacts can be mitigated by restricting the use of explosives in open water or in close proximity to fish-bearing lakes and streams, and by requiring that the use of explosives in intertidal areas be limited to low tides when these areas are dewatered. Mitigation to protect fish eggs may include limiting the timing of seismic work. This restriction is considered by DO&G on a case-by-case basis as a condition for obtaining a geophysical exploration permit. Other restrictions include requiring that seismic activities be set back far enough from fresh water fish spawning areas that shock waves are reduced to safe levels before reaching incubating eggs during sensitive stages of development (Fink, 1996).

Gas Blowouts. If a natural gas blowout occurs, marine fishes, eggs, and larvae near the blowout point probably would be killed. Natural gas condensates in the water column would be hazardous to any fish, eggs, or larvae that were exposed to high concentrations. However, a plume of natural gas vapors and condensates would disperse rapidly from the blowout site and is not expected to be hazardous to fisheries resources. Natural gas exploration and development in Cook Inlet probably would have no adverse effects on pelagic, semidemersal, or demersal fish populations (MMS, 1996: IV.F.2).

Oil spills. There are at least five possible ways oil can affect fish populations: (1) eggs and larvae can die in spawning or nursery areas due to coating or direct toxic effects; (2) adults can die or fail to reach spawning grounds; (3) spawning behavior may be changed; (4) local food species of the fish or larvae may be adversely affected or eliminated; and (5) sub-lethal effects may reduce fitness and affect the ability to endure environmental stress. The magnitude of effects depends on environmental factors that influence the concentration and distribution of oil in marine waters (MMS, 1995: IV.B.1-30). Oil, (particularly the water soluble fractions) would be more vertically mixed in an Upper Cook Inlet than occurred in Prince William Sound with greater potential for exposure to fish (ADF&G, 1998:2-4)

Following the EVOS, hatchery salmon and wild salmon from both intertidal and upstream spawning habitats swam through oiled waters and ingested oil particles and oiled prey as they foraged in the Sound and emigrated to the sea. As a result, three types of early life-stage injuries were identified: 1) growth rates in juvenile pink salmon from oiled parts of Prince William Sound were reduced. 2) there was increased egg mortality in oiled versus un-oiled streams and, 3) possible genetic damage, which is under investigation (EVOSTC, 1996:13). Oil, (particularly the water soluble fractions) would be more vertically mixed in an Upper Cook Inlet than occurred in Prince William Sound with greater potential for exposure to fish (ADF&G, 1998:2-4).

In the years preceding the EVOS, returns of wild pink salmon in Prince William Sound varied from a maximum of 21.0 million fish in 1984 to a minimum of 1.8 million in 1988. Since the spill, returns of wild pinks have varied from a high of about 14.4 million fish in 1990 to a low of about 2.2 million in 1992. Because of the tremendous natural variation in adult returns, however, it is difficult to attribute poor returns in a given year to injuries caused by *Exxon Valdez* oil (EVOSTC, 1996:13).

Pacific herring spawned in intertidal and subtidal habitats in Prince William Sound shortly after the EVOS. A significant portion of these spawning habitats as well as herring staging areas in the Sound were contaminated by oil. Field studies conducted after the spill provided evidence for increased rates of egg mortality and sub-lethal effects in embryos and larvae (Hose et al., 1993; McGurk and Biggs, 1993).

In 1993, there was a crash of the adult herring population in Prince William Sound. A viral disease and fungus were the probable agents of mortality (EVOSTC, 1996:12). In 1994, another pathogen, *Ichthyophonus*, was detected in 30 percent of the 1994 samples compared to five percent of the fish sampled in previous years (EVOSTC, 1995:16). *Ichthyophonus* has a history of causing severe mortality in Atlantic herring and the PWS strain may be even more virulent. (Sullivan, 1996:2). It is possible that stress to the herring population as a result of the oil spill may have made the population more susceptible to VHS (a fish disease)and to *Ichthyophonus*. Herring populations historically fluctuate, and environmental factors and natural variability also should be considered as possible causes of the lesion outbreak and the poor herring returns.

Semidemersal fishes such as Pollock, sablefish, Pacific cod, eulachon, and a number of other regional finfishes tend to inhabit midwaters. Pollock sampled from PWS and Tugidak Island in 1990 following the EVOS showed evidence of fluorescent aromatic compounds,[2] but these dropped substantially in 1991(Collier et al., 1993). Some proportion of the eggs or larvae of semidemersal fish possibly could be contaminated and their viability reduced. Also, eulachon are anadromous and could be oiled when returning to their natal streams to spawn.

Demersal fish populations such as pacific halibut, a number of other flatfishes, and rockfishes inhabit the near-bottom areas of Cook Inlet. An oil spill could expose demersal fishes to toxic effects ranging from sub-lethal to lethal. In general, concentrations of petroleum hydrocarbons (PHC's) beneath the initial surface slick are well below toxic levels for finfishes. However, the magnitude of effects depends on environmental factors that influence the concentration and distribution of oil in marine waters. Some rockfish examined after the EVOS for lesions and elevated levels of hydrocarbons in their bile indicated significant differences between oiled and control locations (Hoffman et al., 1993). At least five rockfish examined were killed by exposure to oil. Analysis of other rockfish showed exposure to hydrocarbons and probable sub-lethal effects (EVOSTC, 1996:15). While no population-level effect was noted, these data indicate some spilled oil reached and exposed demersal fishes to toxic effects.

## Mitigation Measures

The following are summaries of some applicable mitigation measures and lessee advisories that would mitigate potential impacts to fish. For a complete, full text listing of mitigation measures, see Chapter Nine. Title 16 of the Alaska Statutes requires protection of documented anadromous streams from disturbances associated with development.

- Protection from drilling and production discharges -- lessees must use appropriate methods for disposal of muds, cuttings, and produced waters.
- Protection of fish habitat, including fish overwintering areas -- lessees must avoid altering stream banks and obtain approval for the location of crossings on fish streams. Lessees may be required to construct ice or snow bridges if ice thickness at a crossing is insufficient to protect the streambed and the stream bank. Lessees must not operate equipment (except boats) in open water areas of rivers and streams. When a fishbearing waterbody is used as a water source, lessees must use appropriate measures to avoid entrainment of fish. Permanent facilities must be sited minimum distances from fishbearing streams and lakes.
- Protection from seismic activities -- lessees must follow requirements for explosives during onshore seismic activities, and are prohibited from using explosives with a velocity of greater than 3,000 feet per second in marine waters.

[2] Compounds that absorb and emit light, indicating the presence of hydrocarbons.

- Oil spill prevention and control -- lessees must prepare contingency plans addressing prevention, detection, and cleanup of oil spills. Lining, diking and buffer zones are required to separate oil storage facilities from marine and freshwater supplies.

## 4. Effects on Birds

About 100 species of waterfowl, shorebirds and seabirds occur in the Cook Inlet and Susitna areas (Trasky, 1995:1) For a description of Cook Inlet birds and their habitat, see Chapter Three. Cumulative adverse effects on marine and coastal birds from the sale could come from noise and disturbance and alteration of bird populations and habitat, habitat loss, and oil pollution of the marine environment (MMS, 1995: IV.B.1-36).

<u>Habitat loss.</u> Siting of onshore facilities such as drill pads, roads, and oil storage facilities could eliminate or alter some preferred bird habitats such as wetlands. The construction of offshore pipelines could have temporary effects on the availability of food sources of some sea ducks within a mile or two of the construction area due to turbidity and removal of prey organisms along the pipeline route (MMS, 1995: IV.B.1-37).

<u>Noise and Disturbance</u>. Noise and disturbance that may affect marine and coastal birds include geophysical surveys (air guns, and surface explosions), construction, support vessels, vehicle traffic, aircraft overflights, and drilling and production. The responses of birds to human disturbances (including aircraft) are highly variable. These responses depend on the species; the physiological or reproductive state of the birds; distance from the disturbance; type, intensity, and duration of the disturbance; and many other factors. The movement and noise of low-lying aircraft passing near seabird colonies often frightens most or all adult birds off their nests, leaving the eggs and young vulnerable to exposure, predation, and accidental displacement from the nest (Jones and Peterson, 1979). Any form of physical disturbance can have similar consequences. Human intrusions into a colonies of seabirds can result in reduced reproductive success. Eggs, hatchlings, and fledglings are particularly vulnerable to activities which may result in loss of eggs or young, dispersion from the nesting site or rookery, and disruption of vital parent-offspring bonds (Boesch et al., 1987).

Repeated air-traffic disturbance of concentrations of feeding and molting waterfowl and shorebirds on coastal lagoons and other wetlands may reduce the ability of migratory birds to acquire the energy necessary for successful migration. If such disturbance occurred frequently, migration mortality might increase and winter survival of affected birds might be reduced (MMS, 1995: IV.B.1-36).

<u>Gas Blowouts</u>. In the event of a natural gas explosion and fire, birds in the immediate vicinity would be killed. Blowouts of natural gas condensates that did not burn would be dispersed very rapidly at the blowout site thus, it is not likely that toxic fumes would affect birds or their food sources except those very near to the source of the blowout (MMS, 1996: IV.F.2).

<u>Oil Spills.</u> Prevention of and responsive countermeasures for oil spills are particularly critical to assure protection of birds. Direct oil contact alone usually is fatal and often results in substantial mortality of many birds. Oiling of birds causes death from hypothermia, shock, or drowning. The direct effect of oil on a bird is to clog the fine structure of its feathers, which is responsible for maintaining water-repellence and heat insulation. The loss of thermal insulation results in greatly increased metabolic activity to maintain body temperature. As a result, fat and muscular energy reserves are rapidly exhausted, leading to mortality. For these reasons, birds are more likely to succumb from oiling in colder climates. Birds also ingest oil, probably from preening their oiled plumage (NRC, 1985). Some species (e.g., harlequins) can also ingest it by eating oiled prey ADF&G 1996:1). Autopsies of oiled seabirds have revealed, in addition to wasting of fat and muscle tissues, abnormal condition in the lungs, adrenals, kidneys, liver, nasal salt gland, and gastrointestinal tract, and a reduction in white cell count. Relatively small amounts of ingested oil can cause a temporary

depression of egg laying and reduce the hatching success of those eggs that are laid. Oil deposited on eggs from the feathers of the adults can also have an adverse impact on hatching, even in small quantities (ADF&G, 1998:2). The birds most susceptible to oiling are those which are gregarious, spend most of their time on the water, and dive rather than fly up when disturbed (NRC, 1985).

Hundreds of thousands of marine birds are estimated to have died as a result of contact with oil spilled from the *Exxon Valdez* (Heinemann, 1993). Birds injured by the spill include bald eagle, black oystercatcher, common loon, common murre, cormorant, harlequin duck, Kittlitz's murrelet, marbled murrelet, and pigeon guillemot. Murres congregating near their breeding colonies in the western Gulf of Alaska suffered very high mortalities.

Eagles may encounter floating oil while preying on fish and oil contaminated carcasses. Heavily oiled eagle plumage makes flight impossible and may lead to loss of body heat. Oil is also ingested through preening. More than 150 eagles were found dead after the EVOS, although the actual number killed is estimated to be somewhere between 200 to 900 (Bowman and Schempf, 1993). Surveys taken in 1989 indicated that nest failure was 85 percent in oiled areas, compared to 55 percent in lightly oiled or un-oiled areas. In 1990, increases in breeding success suggested that the setback to eagle reproduction was temporary. Researchers estimate that the bald eagle population had nearly recovered by 1994 (EVOS Trustee Council, 1994:11), and an aerial survey of adults in 1995 indicated that the population has returned or exceeded its pre-spill level in Prince William Sound (EVOSTC, 1996:4).

Carcasses of nearly 1,100 murrelets were found after the spill. The oil probably killed many more murrelets than were found, and it is estimated that as much as 7 percent of the marbled murrelet population in the oil-spill area was killed by the spill (EVOSTC, 1996:11).

Murres were severely impacted by the EVOS. Tens, perhaps hundreds of thousands were killed (Piatt et al., 1990). In addition to direct losses of murres, there is evidence that the timing of reproduction was disrupted and productivity reduced. Murres experienced nearly total reproductive failures at every colony monitored by the USFWS within the trajectory of the oil (Nysewander et al., 1993). Based on surveys of index colonies, the spill-area population may have declined by about 40 percent following the spill. Post spill monitoring of productivity at the colonies in the Barren Islands indicates that reproductive timing and success were again within normal bounds by 1993. Numbers of adult murres were last surveyed at those same colonies in 1994. At that time, the local population had not returned to pre-spill levels (EVOSTC, 1996:5).

The number of birds impacted by a spill would depend on the time of year and the density of local bird populations. Spill prevention and response are described in Chapter Five, and would apply to any new development in the Cook Inlet Areawide sale.

If oil development occurs, some alteration of bird habitat can be expected. However, with state and federal government oversight, any activities within the area should not prevent overall bird population levels from remaining at or near current levels.

## Mitigation Measures

The following are summaries of some applicable mitigation measures and lessee advisories that would mitigate potential impacts to birds. For a complete, full text listing of mitigation measures, see Chapter Nine.

- Habitat loss avoidance -- Lessees must identify and avoid sensitive habitat areas and site facilities outside of key wetlands. Permanent facilities must be sited minimum distances from streams and waterbodies.

- Disturbance avoidance -- exploration, development, and major maintenance is restricted within the Redoubt Bay CHA and the Trading Bay SGR; aircraft flying over the Redoubt Bay CHA and the primary waterfowl habitat within the Trading Bay SGR are advised to maintain minimum distances.
- Should development occur in an area where nesting trumpeter swans are present, the following mitigation measure would apply: Surface entry, the siting of permanent facilities, and aircraft operation are prohibited in the vicinity of trumpeter swan nesting sites.
- Bald eagle protection -- lessees must comply with the guidelines of the Bald Eagle Act of 1940, as amended.

## 5. Effects on Marine Mammals

Primary effects that may impact marine mammals include habitat loss, noise and other physical disturbances to the marine environment, and oil spills.

Habitat loss. Habitat loss would be limited to temporary disturbance to some sea otters and harbor seals in the nearshore environment associated with construction of pipelines and transport facilities. Such activities may cause harbor seals and sea otters to haulout and forage in different areas. This disturbance would likely be relatively short term and very localized, and should not affect survival (MMS, 1995:IV.B.1-52).

Noise and Disturbance. Noise and disturbance activities that may affect marine mammals in the sale area include geophysical surveys, marine dredging and construction, support vessels, aircraft overflights, and offshore drilling and production. Marine mammal vulnerability to disturbance depends on the number of animals involved, sensitivity of the species, the presence of preferred habitat in relation to the disturbance, and the characteristics of the disturbance source. Some pinnipeds are known to habituate to strong underwater noises used to deter seals and sea lions from fishing operations. Underwater sounds generated by seismic surveys are below the most sensitive range for pinnipeds, and probably would not greatly affect harbor seal activities (MMS, 1995: IV.B.1-47). Aircraft pose no apparent threat to beluga whales as they have habituated to the aerial traffic in Cook Inlet (Rugh, Sheldon, and Mahoney, 1998:8).

There are no direct studies of harbor seal reaction to waterborne noise due to oil and gas-industry related dredging and construction. However, harbor seals in Kachemak Bay continued to haul out during construction of hydroelectric facilities 1.6 km away (MMS, 1995: IV.B.1-48).

Cetaceans often are observed within a radius of where drilling noise is audible. Reactions to drilling are limited to short-term changes in travel direction to avoid the sound source and short-term increases or decreases in swimming speeds. Both minke and beluga whales have been observed in the vicinity of platforms in the inlet with no apparent deleterious effect. Based on the information presented above, both species temporarily might avoid drilling operations but likely would habituate to drilling operations after some time (MMS, 1995: IV.B.1-51).

Gas Blowouts. If a natural gas blowout occurred with possible explosion and fire, marine mammals in the immediate vicinity of the blowout could be killed. Natural gas and gas condensates that did not burn in the blowout could be hazardous to marine mammals if exposed to high concentrations. Toxic fumes associated with the blowout are expected to disperse quickly and have a minimal effect on marine mammals. It is not likely that these pollutants would affect any marine mammals except those in the immediate vicinity of the blowout. Surface-dwelling marine mammals such as sea otters would be particularly vulnerable to such an explosion. Marine mammal mortality associated with the blowout is not expected to exceed natural mortality rates. Recovery to pre-blowout population levels are expected to occur within a year. Effects of natural gas exploration and development to marine mammals would be minimal (MMS, 1996: IV.F.3).

Oil spills. Spilled oil can affect marine mammals through direct contact with the skin surface, inhalation of petroleum hydrocarbon vapors, ingestion, or through interference with normal behavior. Laboratory studies on phocid seals have also demonstrated that petroleum hydrocarbons may be transported by the blood and distributed to many tissues including blubber, muscle and liver (Williams et al. 1994). The ability of a marine mammal to avoid oil rests on its dependence on the area and avenues of escape. Pelagic dolphins and whales are highly mobile, whereas seals and otters depend on inshore waters where oil tends to accumulate (Geraci and St. Aubin, 1987). Even though cetaceans are very mobile, they may not avoid oil slicks. There were numerous sightings of killer whales in *Exxon Valdez* oil. ADF&G researchers have hypothesized that whales accustomed to ice infested waters may not avoid oil like species found in more temperate climates (ADF&G 1996:3). At greatest risk are seal pups whose insulation is provided by fur rather than by thick blubber. Degradation of their coat by oil and subsequent wetting destroys the insulative barrier, and death from hypothermia may follow (MMS, 1984: IV-B-38). Sea otters are particularly vulnerable to oil contamination because they rely on pelage rather than blubber for insulation, and oiling drastically reduces the insulative value of the fur (Ballachey, et al., 1994). Moreover, attempts to groom can lead to oil ingestion (Geraci and St. Aubin, 1987). It is unlikely that killer whale populations would be affected by a spill event because of the small number and low frequency occurrence of killer whales in Cook Inlet (MMS, 1996: IV.B.1-42). Beluga whales, on the other hand, may be at risk.

Harbor seals and sea otters would be affected by the disturbance associated with cleanup activities following a spill. Cleanup efforts, depending upon their degree and duration, could force these animals to seek food in other, less desirable areas. If a spill and subsequent cleanup occurred in their reproductive habitat, harbor seals may not necessarily move to un-oiled areas. Harbor seals pupped on beaches fouled by *Exxon Valdez* oil (ADF&G, 1996:3)

Marine mammals injured by the EVOS included: harbor seal, killer whale, and sea otter. Estimated mortality as a direct result of the oil spill was about 300 seals in Prince William Sound. Sea otter deaths in the field and in rehabilitation centers totaled 994 (Doroff et al. 1993). The actual number that died was probably much greater (Lipscomb et al. 1994). Fourteen killer whales disappeared from the AB pod in Prince William Sound from 1989-91. There is a spatial and temporal correlation between the loss of these whales and the EVOS, but there is no clear cause-and-effect relationship (Dahlheim and Matkin, 1994).

### Mitigation Measures

The following are summaries of some applicable mitigation measures and lessee advisories that would mitigate potential impacts to marine mammals. For a complete, full text listing of mitigation measures, see Chapter Nine.

- Lessees must comply with the Marine Mammal Protection Act of 1972 which prohibits disturbing marine mammals
- The use of explosives for seismic activities is restricted in marine waters.
- Oil spill prevention -- Lessees are required to implement oil spill prevention, control, and countermeasures plans (see Chapter Five).
- Should the Beluga whale be listed under the federal Endangered Species Act, additional mitigation measures may be required at the plan of operations stage.

## 6. Effects on Terrestrial Animals

**Moose and Caribou:** Moose are abundant throughout the uplands of the Cook Inlet and Susitna areas. Calving and wintering habitat are considered particularly critical. Coastal lowlands support relatively high concentrations of calving moose, and river drainages constitute essential moose wintering range. Caribou are present in low numbers on the Kenai Peninsula. The Kenai Lowlands Caribou Herd calves in the vicinity of the Kenai airport and along the coast south of the Kenai River (Trasky, 1995:3).

Habitat loss. Rapid population increases on the Kenai Peninsula have led to habitat loss as new housing and commercial developments are constructed. In spite of these developments, moose populations have declined little over the last 10 years. It is unlikely that oil and gas exploration and development will result in significant habitat loss beyond that which is already occurring due to other development. Therefore, population declines as a result of oil and gas development are not expected.

While habitat loss can affect caribou populations, increased predation by dogs, and animals killed by highway vehicles have been identified as the primary factors in recent caribou population declines in the Kenai Lowlands Caribou Herd (KLCH) (Spraker, 1996). Road construction on the Kenai Peninsula may be allowing dogs greater access to caribou habitat leading to increased predation on their summer range. Oil and gas exploration and development may lead to some new road construction. Depending on location relative to caribou use areas, these roads may provide greater access to caribou habitat and the potential for increased predation similar to that resulting from roads constructed with other types of development.

In recent years there has been some loss of KLCH habitat in the wetlands north of Kenai airport due to road construction. The roads and associated traffic have displaced caribou from this preferred calving area to the gas fields south of Soldotna. Although alteration or loss of caribou calving and summering habitat could lead to a decline in caribou populations, mitigation measures 6, 7, and 8 were developed to ensure that facility siting and activities minimize impacts. Measure 25 specifically protects the KLCH. Surface entry is prohibited within the core caribou calving area except for seismic exploration, which will be allowed from October 16 to March 31. Exploration and development activities are restricted between April 1 and October 15 within the core caribou summer habitat. Permanent roads or facilities other than production wells, will also be restricted or prohibited within this area. Further, as specific projects are proposed, habitat use evaluations will be completed as part of the plan of operations review and development of mitigation measures. Therefore, caribou habitat loss and resulting population decline is not expected at this time as a result of oil and gas leasing, exploration, and development.

Noise and Disturbance. Noise and disturbance that may affect terrestrial animals include geophysical surveys, construction, vehicle traffic, aircraft overflights, and drilling and production. Caribou cow and calf groups are most sensitive to human disturbance during the post calving period. The primary sources of disturbance from oil and gas development are above ground pipelines which can restrict caribou and moose movement, ground-vehicle traffic, aircraft, and human presence near cows with newborn calves (ADNR, 1995:62). Some brief displacement of moose and other terrestrial mammals could occur because of noise and movement of aircraft traffic and marine vessel support traffic.

Gas Blowouts. If a natural gas explosion and fire occurred on land or very near the coast, terrestrial animals could be killed or displaced, particularly if some forest areas were burned as a result of the accident. However, losses to any one terrestrial mammal population are not expected to exceed natural mortality or, if they do, the losses are expected to be replaced within one to a few years (MMS, 1996: IV.F.4).

Oil Spills. In general the effects of an oil spill on moose and caribou would result from oil contamination of individual mammals, contamination of habitats, and contamination of some local food sources (MMS, 1995, IV.B.1-66). Regional populations are not expected to be affected by oil spills or by the overall effect of exploration and development activities (MMS, 1995, IV.B.1-69).

**Wolves:** The effects of direct habitat loss on wolves would be negligible. The abundance of wolves in the sale area is ultimately determined by the availability of prey and game management re-location efforts. The ability of adults to provide food is the key determinant in wolf-pup survival. Reduction in prey species, such as moose, could reduce wolf populations (USF&WS, 1987:126).

Disturbance. Wolves are unlikely to be disturbed by development. Wolves readily habituate to human activity. During construction of the Dalton Highway and TAPS, wolves readily accepted handouts from construction workers (USF&WS, 1987:127). Primary sources of disturbance are seismic activities and aircraft traffic. Helicopters generally invoke a stronger response from wolves and foxes than fixed-wing aircraft. Ice roads connecting well sites and supply areas would provide a source of vehicle disturbance. Impacts of seismic exploration and drilling on wolves is unknown (USF&WS, 1986:535).

Oil Spills. The general effects of an oil spill on wolves are similar to that of other terrestrial animals. The potential effects of oil spills include contamination of individual animals, contamination of habitats, and contamination of some local food sources. Furbearers, particularly foxes, may be attracted to dead oiled wildlife at a spill site. Foxes and coyotes may be attracted to the human activity at a spill site by the possibility of finding food or garbage. In the event of a large oil spill contacting and extensively oiling habitats with concentrations of wolves and foxes, the presence of humans, along with vehicle and aircraft traffic are expected to cause disturbance and displacement of these animals during cleanup operations.

## Mitigation Measures

The following are summaries of some applicable mitigation measures and lessee advisories that would mitigate potential impacts to terrestrial animals. For a complete, full text listing of mitigation measures, see Chapter Nine.

- Habitat loss avoidance -- exploration activities must be supported by air service, an existing road system or port facility, temporary roads, or by vehicles which do not cause significant damage to the ground surface or vegetation. Construction of permanent roads for exploration in most instances, is prohibited and use of gravel filling for exploration is discouraged. Permanent facilities must be sited minimum distances from stream and lakes.
- Whenever possible, onshore pipelines must utilize existing transportation corridors and be buried where soil and geophysical conditions permit.
- Surface entry is restricted in state game refuges and critical habitat areas.
- Exploration facilities must be consolidated, temporary, and must not be constructed of gravel, except for drill pads, airstrips and roads.
- The ACMP, 6 AAC 80.070(b)(12), requires that facilities be sited to the extent feasible and prudent to allow free passage and movement of fish and wildlife.
- Exploration and development activities are restricted within the core calving and core summering habitat areas of the Kenai Lowlands Caribou Herd.

**Bears:** Brown and Black Bears inhabit the Cook Inlet and Susitna regions. Both species are concentrated along salmon streams in late summer and fall. The Kenai Peninsula brown bear population appears to be stable at around 250-300 bears (ADF&G, 1998a). Brown bear management objectives have been to maintain a population of 250 brown bears. Hunting seasons have been adjusted over the years to meet the management objectives (DOF, 1997:10).

The Kenai Peninsula brown bears are genetically the same as other brown bears in southcentral and Interior Alaska, but are isolated geographically and are managed as a separate population. (Alaska Office of the Governor, 1998) The population is apparently stable but there is concern about future human-bear conflicts.

Responding to concerns about the long-term health of this isolated population of bears, ADF&G in November 1998 added the Kenai Peninsula Brown Bear to its list of "species of special concern." The listing will focus research and management attention on the population and is intended to prevent the bears from being listed by the federal government as a threatened or endangered species at some point in the future. A team of state and federal biologists has begun a major research project on the bears, looking at habitat needs, rate of reproduction and movement patterns. (Office of the Governor, 1998)

ADF&G is beginning to develop a brown bear conservation strategy plan, and will work closely with local communities, land managers and Kenai residents to help them understand the needs of the bears and to balance the needs of the bears with other needs such as forest management, oil and gas development, tourism and fishing. (Office of the Governor 1998). ADNR will participate in the development of the state brown bear conservation strategy. After the conservation strategy plan is completed, ADNR will initiate a process for modifying the Kenai Area Plan in order to incorporate the strategy plan's recommendations. The process for modifying the Kenai Area Plan will be consistent with 11 AAC 55.030(f). (ADNR, 1998).

Adding the Kenai brown bears to the state's list of "species of special concern" has no regulatory effect or legal implications. Regulated hunting for bears will still be allowed on the Kenai and the action does not impose any special restrictions on businesses, landowners or recreational users in the area. (Office of the Governor, 1998).

This finding may be amended to incorporate any new significant information about the status of the Kenai Peninsula brown bears, and the results of the brown bear conservation strategy and if warranted, new mitigation measures may be added to protect the bears.

<u>Habitat Loss</u>. Exploration and development activities may result in the fragmentation, reduction and lowering of quality habitat. The availability of security cover is considered important in how brown bears are influenced by human activities. Brown bears are at least twice as likely to be displaced from an area where they can see or be seen. Most of the major salmon stream systems important to Kenai brown bears and portions of identified movement corridors are included in the sale vicinity (ADF&G, 1998:3-3). Brown bears require large blocks of wilderness habitats and secure travel corridors connecting them. The movement corridors provide secure cover so bears can safely travel to and from important habitats, and function to prevent the isolation of bears into "island populations." Bears on the Kenai Peninsula seasonally congregate along portions of salmon streams. Upland habitat adjacent to the riparian areas is used for loafing, cover, and other foraging when not feeding on salmon. Bears feed on salmon within movement corridors and access habitat around dens of large lakes on the Peninsula. Oil and gas activities can affect individual bear populations by increasing the frequency of high energy-cost flight responses by bears or displacing bears from the areas of human use. Figure 3.6 shows the location of movement corridors (ADF&G, 1998:3-3).

<u>Disturbance.</u> Brown bears may be subject to disturbance from oil and gas activity. Primary sources of disturbance include seismic activity, vehicle traffic, and aircraft. Seismic activity which occurs in winter may disturb denning bears. Studies have found that radio-collared bears in their dens were disturbed by seismic activities within 1.2 miles of their dens. This was demonstrated by an increased heart rate and greater movement within the den (USF&WS, 1987:128). Two incidents in 1998 involving seismic crews on the Kenai Peninsula resulted in den abandonment. In one of the incidents, the seismic worker was fatally mauled. In both cases the crews were walking in close proximity to the dens (Fink, 1999).

<u>Road Development.</u> The greatest concern regarding bear populations is road development (DOF, 1997:11). Road development increases opportunities for bear-human interactions and reduces the value of bear habitat. New roads could increase mortality rates through killing of bears by industry personnel or improving the access of hunters, poachers, or other resource users (ADF&G, 1998:3-3).

Human-Bear Interactions. During exploration and development, human activity may attract foraging bears, especially to refuse disposal areas. Omnivores are attracted to food and food odors associated with human activity, and may become conditioned to non-natural food sources (Baker 1987). This may pose a threat to human safety and the potential need to shoot "problem" animals (ADF&G, 1996:2). Wildlife biologists express concern about the increasing trend and brown bear mortalitys in defense of life and property (DLP kills) and potential for additional mortality from human encroachment into bear habitat. The number of non-hunting kills, which includes DLPs, research mortalitys and other known human-caused mortalitys increased each year from three in 1991 to ten in 1995, resulting in the closure of the 1995 hunting season. Since 1986, approximately a third of the DLPs occurred near homes, another third are associated with hunting, and the last third resulted from different activities such as fishing, hiking, and ranching etc. (DOF, 1997:11). In the fall of 1995, the hunting season was closed by emergency order because of DLP kills. The fall 1996 season was also canceled, but hunting was allowed during the spring of 1966 and 1997. The 1997 fall season was closed by emergency order when a sixth female bear was shot by a hunter in defense of life.

Oil Spills. The effects of potential oil spills on bears include contamination of individual animals, contamination of coastal habitats, and contamination of some local food sources. Bears depend on streams, mudflats, and rivers during the summer and fall for catching salmon, clams and other food sources. If an oil spill contaminates beaches and tidal flats along the coast, bears are likely to ingest contaminated food sources (MMS, 1995: IV.B.1-66).

### Mitigation Measures

The following are summaries of some applicable mitigation measures and lessee advisories that would mitigate potential impacts to brown bears. For a complete, full text listing of mitigation measures, see Chapter Nine.

- Waste management -- lessees must use appropriate methods of garbage and putrescible waste disposal to minimize attracting bears.

- Oil spill prevention -- Lessees are required to implement oil spill prevention, control, and countermeasures plans (see Chapter Six). In addition, they are required to site facilities away from lakes and streams and critical wetlands, to provide adequate protection for on-site oil storage, and to locate pipelines to facilitate oil spill cleanup.

- Disturbance -- For projects in close proximity to areas frequented by bears, lessees are encouraged to prepare and implement bear interaction plans. Operations can be designed to minimize conflicts between bears and humans and minimize attraction of bears to facilities and work camps.

- Den site protection - before field work can begin, known locations of den sites are identified and avoided by 1/2 mile during denning season. If new dens are encountered in the field, they must be immediately reported to ADF&G.

  In 1998, in response to recent bear data analysis by ADF&G, ADF&G and ADNR developed one new mitigation measure and two lessee advisories for protection of the Kenai Peninsula brown bear population.

- Bear movement corridors - Exploration activities will be allowed only between November 15 and March 31 within he brown bear movement corridors around Skilak Lake, Tustumena Lake, along the upper Anchor River drainage, and at the head of Kachemak Bay. If data indicate that brown bear movement will be hindered by development and production activities, lessees may be required to locate facilities outside these corridors.

- Feeding concentration areas - lessees may be required to locate exploration and development facilities beyond the 500-foot buffer along anadromous fish bearing streams.

## C. Effects on Cultural & Historic Resources

In cooperation with the Office of History and Archaeology, DO&G has reviewed the Alaska Heritage Resources Survey (AHRS) to assess the potential effects of oil and gas activities on cultural and historic resources within the Cook Inlet Areawide sale region. The AHRS is an inventory of all reported historic and prehistoric sites within the state of Alaska. The fundamental use of the AHRS is to protect cultural resources from unwanted destruction. Access to the AHRS is closed to the general public, however authorized users include agency representatives, researchers, and individuals conducting cultural resource surveys aimed at protecting such sites (AHRS, 1998).

There are more than 530 reported historic or prehistoric sites within the Cook Inlet Areawide region, including the Swanson River Unit #1 discovery well. Sites date back to prehistoric periods of Dena'ina and Eskimo occupations, as well as historic periods of Russian and Euroamerican occupations. Sites may be listed as historic if they are 50 or more years old. Sites may include house pits, burial grounds, cache pits, fish camps, culturally modified trees, rock shelters, stone and bone tools, middens, petroglyphs and pictographs, settlement sites, trapping and mining cabins, trading centers, forts, and military sites. Identification of these sites is largely driven by development projects, such as road and highway construction or community expansion (AHRS, 1998).

Sites are often clustered near natural features, such as river mouths, bluffs, and natural transportation routes. The western shore of Cook Inlet has seen very little archaeological survey and the actual number of historic sites is unknown. Numerous sites are scattered along the east bank of the Susitna River and along the Iditarod trail route, although data is sparse to the west of the Susitna River. Other drainages, such as the Theodore, Lewis, Beluga, Chuitna, Chakachatna, and Kustatan Rivers and Nikolai Creek have little data. In contrast, the more populated areas and federal park units have been surveyed more intensively. Many sites have been discovered in the Houston and Big Lake region as well as in the Wasilla and Palmer area. Over 250 buildings and farm sites at Palmer are from the Matanuska Valley agricultural colony period of the 1930s, however, these sites are outside of the sale region. Sites are clustered around existing communities of Tyonek, Knik, Eklutna, and Eagle River. Several sites exist at both Fort Richardson and Elmendorf Air Force Base. There are more than 100 sites (historic buildings and structures) within the city of Anchorage. Many sites are scattered along Turnagain Arm. On the Kenai Peninsula there are more than 150 sites within the Cook Inlet Areawide region (AHRS, 1998). The area south of the Kenai River is well known historically and archaeologically, although the townships north of Kenai are only sporadically surveyed (AHRS, 1998). The Anchor River drainage is largely unexplored. Clusters of sites are reported around Anchor Point, Kasilof River, and the Kenai River. There are more than 50 sites in the Kenai city area, the majority of which are historic (AHRS, 1998).

Onshore prehistoric and historic sites may be affected by construction of pipelines, onshore-support facilities, increases in industrial personnel and supporting populations, and accidental disturbance. Effects on submerged archaeological resources may result from activities such as laying pipelines, dragging anchors of operating and supply vessels, and anchoring drill rigs (MMS, 1995: IV.B.1-84).

Gas Blowouts. Disturbance to historical and archeological sites might occur as a result of onshore activity associated with accidents such as a gas blowout or explosion. Cleanup after such accidents could result in disturbance by cleanup workers in the vicinity of the accident site. Archaeological resources in the immediate vicinity of the blowout might be destroyed (MMS, 1996: IV.F.5).

Oil spills. The EVOS cleanup demonstrated that archaeological resources generally were not directly affected by the spill. The largest effects came from vandalism, because more people knew about the location of the resources and were present at the sites. That knowledge increased as the population and activities increased during the cleanup process (AHRS, 1998).

The effects of cleanup were slight during the EVOS because the work plan for cleanup was constantly reviewed, and cleanup techniques were changed as needed to protect archaeological and cultural resources. The effects from oil spills and cleanup operations on archaeological and cultural sites in the sale area would be similar in types of effects but varying in degree depending on the level of exploration. If oil is found, the potential effect will depend on the level of development (Bittner, 1993).

"It is the policy of the state to preserve and protect the historic, prehistoric and archeological resources of Alaska from loss, desecration and destruction . . . " AS 41.35.010. Existing statutes, which apply to both known sites and newly discovered sites, are:

- AS 41.35.200(a) prohibits a person from unlawfully appropriating, excavating, removing, injuring or destroying any historic, prehistoric, or archeological resources of the state. "Historic, prehistoric, or archeological resources" include "deposits, structures, ruins, sites, buildings, graves, artifacts, fossils, or other objects of antiquity which provide information pertaining to the historical or prehistoric culture of people in the state as well as to the natural history of the state." AS 41.35.230(2). Violators of this statute are subject to criminal (misdemeanor) penalties and civil penalties (fines up to $100,000 per violation). AS 41.35.210-215.

- AS 41.35.200(c) prohibits the unlawful destruction, mutilation, defacement, injury to, removal of or excavation of a grave site, tomb, monument, gravestone, or other structure or object at a grave site, even if the grave site appears to be abandoned, lost, or neglected. Violators of this statute are subject to the same penalties listed above for AS 41.35.200(a).

**Mitigation measures.**

The following are summaries of some applicable mitigation measures that would mitigate potential impacts to historic and cultural uses. For a complete, full text listing of mitigation measures, see Chapter Nine.

- Education -- lessees are required to conduct training for all employees and contractors on environmental, social, and cultural concerns in the sale area.
- Protection of historic and archeological sites -- prior to exploration activities involving ground disturbance, and subsequent development, lessees must conduct an archeological inventory. If any objects are discovered at any time, they must be reported, and appropriate protective measures followed.

## D. Effects on Subsistence uses

Some communities depend on the continued use of subsistence resources. Many residents participate in harvesting locally available resources because they value the self-sufficiency, health benefits, or family and cultural traditions accompanying these harvests (ADF&G, 1985b:924). Chapter Four describes subsistence use patterns for various communities. Subsistence use of the region will be affected by any changes in the distribution and abundance of harvested species. The range of possible cumulative impacts on subsistence are potential reductions to fish and wildlife populations, potential damage to their habitats, possible loss of access to harvest areas or increased public access which results in increased competition, and oil spills (ADNR 1993:45).

Subsistence use of the sale area will be affected by any changes in the distribution and abundance of harvested species. Section "b" of this chapter describes the potential impacts to fish and wildlife populations due to habitat loss, disturbance, and oil spills, and the mitigation measures to maintain fish and wildlife populations. Additional site-specific and project specific mitigation measures may be required later if exploration and development take place. To completely ensure the maximum protection of the sale area, continued re-evaluation by the state's resource agencies will be necessary.

Noise and Disturbance. Some oil and gas activities may disturb marine mammals and displace them from seasonal feeding grounds. Underwater noise could disrupt communication, interfere with mating, affect prey capture, cause avoidance of traditional feeding areas or migration routes, or result in hearing loss. A study conducted by Hubbs Marine Research Institute and contracted by the American Petroleum Institute examined the behavior of captive Beluga whales in response to recorded playbacks of semi-submersible drilling noise. Playback of drilling sounds to captive Beluga whales did not result in behavioral changes or increases in stress-related hormones. Because the hearing sensitivity of Beluga whales declines rapidly below 4kHz, they would be less sensitive to lower frequencies common to drilling noise than to higher frequencies used for communication and echolocation. Sound levels are higher for drillships than semi-submersibles because the hull of the ship couples sound to water better than the pontoons and upright supports of the semisubmersible. (API, 1986). Disturbance to Beluga whales from construction and drilling would be higher in deeper water relative to shallower water areas of Cook Inlet, because sound levels are lower at shallower depths, especially at lower frequencies (API, 1986:20). Results obtained from experience with captive animals may not reflect natural processes.

The potential for Beluga whales to be displaced from traditional hunting areas or avoid key feeding areas would be related to the time of year, and the proximity of the drilling operation to river mouths and lagoons where prey, such as salmon school or spawn. Disturbance would also be related to water depth, and the particular tonal components of the drill rig's sound signature. As discussed in Chapter Four, most Beluga hunting takes place in the upper inlet from Anchorage to the Beluga River, and favorite locations include the mouths of the Susitna, Theodore, and Beluga Rivers. Most hunting occurs between mid-April and mid-October (Stanek, 1994:11).

Access. As new discoveries are made, the number of development-related facilities may increase, and portions of the developed areas could be closed to public access, reducing the area available for subsistence activities. At the same time, increased public access to hunting, fishing, and trapping areas, due to construction of new roads, could increase competition between user groups for subsistence resources.

Gas Blowouts. If a natural gas blowout occurred, subsistence harvest of any species in the vicinity could be affected. Access to the immediate vicinity by subsistence hunters may be limited for a short period of time while the blowout is brought under control and the gas vapors and condensates disperse. Subsistence resources in the immediate vicinity would probably be killed. Natural gas and condensates that did not burn in the blowout would be hazardous to any organisms exposed to high concentrations. However, natural gas vapors and condensates would be dispersed very rapidly from the blowout site (one km downwind for about one day) and would affect only those species in the immediate vicinity of the accident. While such an effect would be short term and localized and would not be likely to measurably affect the regional population of any species, it could cause disruption to subsistence harvests in the area of the blowout. However, this disruption would be short term and would not cause any species to become locally unavailable for more than one season (MMS, 1996: IV.F.4).

Effects of Platform Discharges on Marine Food Species. In response to concerns that subsistence food resources may be contaminated by production platform discharges as well as runoff from urban sources, EPA initiated a pollution study for Cook Inlet in 1997. The study was conducted specifically to provide information to characterize potential human health risks associated with exposure to contaminants detected in subsistence food items harvested from Cook Inlet by members of four Alaskan subsistence villages: Tyonek, Seldovia, Port Graham, and Nanwalek. More than 100 samples of subsistence fish, shellfish, and marine plants were tested for dioxins/furans, PAHs, pesticides, PCBs, and metals including inorganic arsenic, barium, cadmium, chromium, methyl mercury, and selenium (EPA, 1998a)(EPA, 1998c).

Preliminary results indicate that contaminant levels in fish and plants are some of the lowest ever detected by EPA. Several groups of chemicals (dioxins/furans, Aroclor PCBs, and PAHs) were rarely detected. For almost every contaminant tested for by EPA, concentrations were either completely non-detectable or were below levels of concern. Laboratory results did show three contaminants in several food items at concentrations that might pose a health risk to people who eat them. PCBs and traces of mercury were found in sea bass, but "[t]he concentrations of PCB's and methyl mercury are very low relative to what's been found in other studies elsewhere, and are at or below typical background levels." (EPA, 1998c). Cadmium was detected in snails, chitons, and octopus likely attributable to natural glacial deposits. EPA is determining if the cadmium concentrations reflect background concentrations or are elevated due to human activity. Oddly, a pesticide called dieldrin was detected in king salmon. EPA plans to reanalyze the salmon to ensure that initial lab work was accurate (EPA, 1998a). The three contaminants may pose a slight health risk to humans depending on how much is eaten, how often it is consumed, and how the food is prepared (EPA, 1998c).

Preliminary results of the EPA subsistence foods study concur with other pollution studies of Cook Inlet: Contaminant levels (regardless of their source) in sediments and tissues are at background levels or are undetectable, and do not pose a threat to Cook Inlet biota (See Chapter Five, section on marine water quality).

<u>Oil spills.</u> In the event of a major oil spill, subsistence users would experience resource losses. Such losses would include the lack of resource availability, accessibility, or desirability for use. Reductions in subsistence-harvest levels for specific resources could extend for more than a year (MMS, 1995: IV.B.1-81). Subsistence harvests of fish and wildlife, in most of the fifteen predominately Alaskan Native communities in the EVOS area declined substantially following the spill. The reasons for the declines include reduced availability of fish and wildlife to harvest, concern about possible health effects of eating contaminated or injured fish and wildlife, and disruption of lifestyles due to cleanup and other activities (EVOSTC, 1996:20).

The social consequences of an oil spill could be serious. This is especially so in communities where subsistence is a core cultural institution with complex social meaning. The *Exxon Valdez* experience showed heightened concern over the health effects of eating contaminated wild foods and the need to depend on the knowledge of others about environmental contamination. This loss of control for individuals and communities would be increasingly stressful over the period of time needed to modify subsistence-harvest patterns by selectively changing harvest areas. If available, searches for uncontaminated resources, such as clams and mussels, would require greater amounts of time because of the distances involved. A large-scale or localized kill of species by environmental contamination forces people to follow the wasteful practice of harvesting smaller and undersized subsistence resources to achieve previous harvest levels (Fall, 1993).

There could be reductions in the amount of subsistence food shared with other households, received from other families, and available for sharing with elders, who are especially affected by the disruption of subsistence activities. Substantial changes in these and other aspects of subsistence activities take away the means by which people derive order and meaning from their lives and introduce uncertainty and confusion (MMS, 1995: IV.B.1-82).

### Mitigation measures and Lessee Advisories.

The following are summaries of some applicable mitigation measures and lessee advisories that would mitigate potential impacts to subsistence. For a complete, full text listing of mitigation measures, see Chapter Nine.

- Harvest interference avoidance -- The commissioner may restrict lease-related use to prevent conflicts with subsistence and commercial fishing operations. Lessees must cooperate with agencies and the public to avoid conflicts by selecting alternative sites or implementing seasonal restrictions on certain activities, by directional drilling, subsea completion techniques, and other technologies deemed appropriate, and by siting permanent facilities a minimum distance from rivers.
- Unrestricted public access -- public access to the leased area is restricted only within 1,500 feet or less, of onshore drill sites, buildings, and other related structures.
- Construction of permanent roads may be prohibited.
- Oil spill prevention -- Lessees are required to implement oil spill prevention, control, and countermeasures plans (see Chapter Six). In addition, they are required to site facilities away from lakes and streams and critical wetlands, to provide adequate protection for on-site oil storage, and to locate pipelines to facilitate oil spill cleanup.

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